MYCOLOGIA

OFFICIAL ORGAN OF THE MYCOLOGICAL SOCIETY OF AMERICA

VOL. XXVII NOV.–DEC., 1935 NO. 6

THE NUCLEAR CYCLE IN HERPOBASIDIUM FILICINUM WITH A DISCUSSION OF THE SIGNIFICANCE OF HOMOTHALLISM IN BASIDIOMYCETES [1, 2]

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(WITH PORTRAIT AND 4 FIGURES)

The first record of the species under discussion was made by Rostrup (1881) who distributed and described it as *Gloeosporium filicinum* Rostr. in Thümen's exsiccati, Mycotheca Universalis No. *2083*. It was later independently described as *Exobasidium Brevieri* by Boudier (**1900**), who misinterpreted the character of the basidia. It was Lind (**1908**) who first recognized the true morphology of the fungus and erected the genus *Herpobasidium* with *H. filicinum* (Rostr.) as the type species. He placed the genus in the Stypinelleae of the family Auriculariaceae. Lind later (**1913**) added a second species, *H. Struthopteridis* (Rostr.) Lind based on *Gloeosporium Struthopteridis* Rostr. without, however, giving an adequate description. This species occurs on *Struthropteris germanica*.

[1] Address of the retiring President of the Mycological Society of America given at the Pittsburgh meeting.

[2] Contribution from the Department of Botany, University of Toronto. The writer gratefully acknowledges the assistance of Dr. S. M. Pady who prepared the slides and to Dr. Elizabeth Astrom Thompson who made the drawings for figure 3.

(MYCOLOGIA for September–October (**27**: 439–552) was issued October 1, 1935)

Herpobasidium filicinum (Rostr.) Lind is fairly widespread in northern Europe on *Aspidium Filix-mas* and *Aspidium Dryopteris*, and has been reported from Norway by Lind (**1908**) on *Aspidium Phegopteris* and *Cystopteris montana*. So far as I have been able to determine the species is unrecorded for North America. It has been found, however, in three localities in Canada. The first collection was made by the writer in a swamp south of Aurora, Ontario, in June 1932, and it has been collected there each year since that time. A second collection was made at Centreton, Ontario, June 5, 1933, by Mildred K. Nobles. It is also known from a collection made by A. E. Roland, June 25, 1933, near Morristown, Kings Co., Nova Scotia. All these collections are on *Thelypteris* (*Aspidium*) *Dryopteris*.[3]

Lind (**1908**) has given a good account of the organism and a detailed description need not be repeated. Certain general features are, however, worthy of mention. When mature, that is during basidiospore production, one finds the affected fronds of *Thelypteris* showing on the upper surface uniformly scattered somewhat angular, small brownish spots. On the under surface of these discolored areas a conspicuous white mould-like growth is visible. An examination of these spots with the aid of freehand sections shows an abundant intercellular mycelium. Branches of this mycelium emerge in fascicles through the stomata and these threads continue to branch and radiate in all directions more or less parallel to the leaf surface. Such hyphae emerge from all the stomata in the discolored area, and intertwine, thus forming the white mould-like patches which form a conspicuous feature of affected fronds. There is little or no gelatinization of the cell walls of these hyphae as is the case in a considerable number of the parasitic species in this group. A careful examination has failed to reveal any connection of these external threads with the epidermal cells. They are merely branches of the intercellular mycelium which grow to the surface of the leaf through the stomata for fructification. The basidia ultimately develop from the end cells of the external mycelium, or from side branches. These basidia when mature are uniformly two celled with stout sterigmata.

[3] Since the above was written a collection on the same host made by Prof. H. H. Whetzel, June 13, 1935, near White Lake, Jamesville, New York, has been received.

One of the most conspicuous characters evident in freehand sections cleared in lacto-phenol is the presence of prominent coiled haustoria (FIG. 1*a*). These are figured and described by Lind

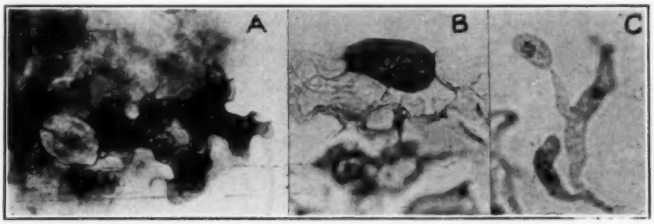

FIG. 1. *A*, haustoria in mesophyll cells; *B*, haustorium in epidermal cell (note hyphal connection to intercellular mycelium); *C*, microphotograph of basidium showing nucleus of lower cell in the spore.

(1908). The development of these has not been studied in any detail but they may occur in any cell of the mesophyll in the discolored areas and not infrequently also in the epidermal cells. As noted by Lind they are at first thin-walled and colorless, later becoming brown, due to pigment in the walls which become considerably thickened. They are of larger diameter than the intercellular or external mycelium and may become septate. Cytological examination shows that the cells of these haustoria are binucleate like the intercellular mycelium. When they occur in the epidermal cells it is evident that they have their origin from the intercellular mycelium, not from the external hyphae (FIG. 1*b*).

Little can be said with certainty concerning the biological history of the fungus. The evidence from field observations indicates that the fungus is systemic and perennial, presumably overwintering in the rhizomes. Infected fronds are recognizable as soon as they begin to expand in early May. There is no hypertrophy. Early in the development of the frond, the fungus seems to become localized in certain areas in the mesophyll which soon become discolored. This localization may be correlated with the development of the haustoria. There is no evidence that the fungus spreads to healthy fronds during the season. When and at what stage in the development of the host the infection occurs which results in the systemic invasion is a question on which there is no

information at present. The basidiospores are thin walled and probably short lived. It may well be that infection occurs in the buds on the rhizome or perhaps in young sporelings.

CYTOLOGICAL INVESTIGATION

Because this species developed consistently two celled basidia a cytological study of the nuclear history seemed desirable. Experience in the rusts has shown that the presence of two celled basidia is correlated in every case which has been investigated with some variation in nuclear sequence. So far as I am aware no species outside the Uredinales having this peculiarity has been examined cytologically, though several species of *Septobasidium* are known with two celled basidia.

Material for sectioning was fixed in Formalin-Acetic-Alcohol and Flemming's weaker solution. The latter fixative proved much more favorable than the former. The slides were stained with the triple stain by Dr. S. M. Pady. The primary purpose of the study was to determine the nuclear history rather than the details of nuclear division. It was considered necessary, however, to establish whether or not a fusion of nuclei took place in the young basidium, and the number and position of the divisions which followed in the developing basidium.

The cells of the intercellular mycelium, the haustoria and the external hyphae as well as of the young basidium are binucleate. No uninucleate mycelium was observed. Since, however, the initial point of infection is unknown, no young stages were examined. The two nuclei present in the young basidium fuse (FIG. 3: 1–4). No evidence of a degenerating nucleus has been observed. Figure 3: 1 shows a fusion nucleus with two nucleoli and figure 3: 2 a later stage with one large nucleolus. Figure 3: 3 shows a late prophase with four bivalent chromosomes.

Division figures of the first meiotic division of the fusion nucleus are abundant in the material studied. Figure 3: 4 shows an early metaphase in which it is evident that four chromosomes are present as well as the nucleolus. Two of these chromosomes are elongated, two appear approximately round. What appear to be central bodies are also present. Figure 3: 5 shows a section, oblique to the basidium, in which the nucleolus and one central body with the

four chromosomes are evident. Figure 3: 6 shows the division in anaphase and figure 3: 7, late telophase.

Divisions of the nuclei of the vegetative mycelium are not infrequent. Figure 3: 8 shows a late prophase with the nucleolus and four chromosomes. Figure 3: 9 illustrates a division in anaphase. Nine stained bodies are present, one of which is presumably the nucleolus. Figure 3: 10 shows a division in late telophase. Figure 3: 11 illustrates two nuclei in a haustorial cell, the lower one of which is in prophase with four chromosomes and the nucleolus, while the upper nucleus is in metaphase showing two long and two short chromosomes. Figures 3: 12 and 3: 13 are of basidiospores, the latter preparing to develop a secondary spore.

From this study it seems evident that a fusion of the two nuclei takes place in the developing basidium. The haploid chromosome number is apparently four and four chromosomes appear in the first division of the fusion nucleus of the basidium, indicating that reduction of chromosomes has taken place in this division.

A careful study of the sections failed, however, to show any conclusive evidence for the occurrence of a second division of the nuclei in the cells of the basidium. Because of the nature and size of the basidia and the fact that they occur in a more or less tangled mass, it is difficult to make observations from sectioned material. Not being entirely satisfied from a study of such material that this division was actually absent, several other methods were tried. One of these methods proved favorable and seems worthy of record. Abundant material was available of whole leaves which had been fixed in Formalin-Acetic-Alcohol. Portions of the affected fronds were placed *in toto* in lacto-phenol to which had been added separately or in mixture nigrosin, Cotton blue or acid green. When the material was allowed to stand in this mixture over night the fungus became very heavily stained. By vigorously boiling in clear lacto-phenol, the stain was gradually reduced to a point where the nuclei of the external threads and basidia stood out sharply in a clear cytoplasm. By dissecting off the mat of external hyphae and basidia and teasing this out on the slide in lacto-phenol, abundant material of detached threads and basidia for detailed examination can be made available. The method is not an exact one as it is difficult to determine the point at which the boiling should be stopped. If carried too far the material begins to disintegrate. One out of a dozen trials, how-

ever, will usually give good results. The slides are not permanent but remain clear for several days, during which time they may be studied to advantage, after which the stains gradually fade out.

By the use of this method, hundreds of entire basidia have been examined in all stages of development, and the number and position of the nuclei determined. The diagrammatic figures of figure 4 are all drawn with the aid of a camera lucida from such mounts. From a study of this material it is evident that the cells of the mycelium and the young basidia are binucleate and that the two nuclei fuse in the young basidium (FIG. 4: 16) and then divide once. During this process the basidium may elongate considerably and a septum is finally laid down between the two nuclei dividing the basidium into two approximately equal cells (FIG. 4: 15). Sterigmata then begin to develop from both cells. Commonly the sterigma of the upper cell is merely an elongation of the end of the cell (FIG. 4: 17, 18, 23, 24, 25) and that of the lower cell develops just below the septum, though this is not always the case (FIG. 4: 18, 22). The basidia show a good deal of irregularity in size and shape. Spores soon begin to develop at the tips of the sterigmata.

No evidence for a second division of the nuclei was found. The writer is convinced that no such division occurs in the basidium. The nuclei which are the products of the first division of the fusion nucleus pass into the spores without dividing. On the chance that a division might occur in the basidium and one of the resulting pair of nuclei might abort, a very careful search was made for evidence of this, but none was found.

As the spore begins to form at the end of the sterigma, it may reach a considerable size before the nucleus passes into it. Usually the cell below remains turgid for some time (FIG. 4: 24, 25), but in other cases the cell collapses gradually from below as the cytoplasm advances (FIG. 4: 20). Figure 4: 1 shows a nucleus passing through the neck of the sterigma into the spore. In this case the remaining cytoplasm is confined to the sterigma, the cell below being in a collapsed condition. A number of basidia were observed in which the nucleus had passed into the spore while the cell below and the sterigma were still filled with cytoplasm (FIG. 4: 24, 25). In such cases there is never any evidence of a degenerating nucleus

in the cell below. Figure 1*c* is a photomicrograph of the basidium from which figure 4: 24 was drawn.

Quite commonly an interesting irregularity was observed in the development of sterigmata and spores. These are illustrated in figure 4: 19–22. In some cases two sterigmata develop from a cell (FIG. 4: 22). In others the sterigma of one or both cells tends to branch and a spore starts to develop on each point (FIG. 4: 20, 21). In no case observed do these extra spores reach maturity. One of them receives the nucleus, the other fails to develop (FIG. 4: 20). Species in this and related groups which develop two celled basidia are quite certainly derived through simplification from forms which develop a typical four celled basidium (see discussion below). It seems possible that this abortive attempt to form more than one spore per cell is a reflection of this origin.

In mounts made in the manner described above there are many detached spores. Hundreds of these in which the nuclei are sharply stained have been examined and they are always uninucleate. These spores apparently produce secondary spores as illustrated in figure 4: 26. In no case has any evidence been obtained that the nucleus divides during the formation of the secondary spore. A careful search failed to reveal any case where the nucleus had passed into the secondary spore while it was still attached but several cases were observed of empty spores which had evidently produced a secondary one.

It would appear from this study that in *Herpobasidium filicinum* the mycelium is binucleate and that the dicaryon fuses in the young basidium. A single division follows in which the chromosome number is reduced. The nuclei so formed pass into the spores without further division. Since the mycelium is binucleate so far as observed, the question arises as to the origin of this dicaryon from the uninucleate spore. Unfortunately no observations have yet been made on this phase of the problem. Preliminary efforts to germinate the spores resulted in failure. The writer ventures the suggestion, however, that the first division of the spore nucleus on germination will be found to initiate the binucleate phase. This division represents the second meiotic division which has been delayed.

RELATIONSHIP

The genus *Herpobasidium* is ordinarily included in the Auriculariales, Killermann (**1928**) includes it as a synonym of *Helicobasidium*. It seems best for the present, however, to recognize the genus as distinct. The apparent obligate parasitism and the presence of highly developed haustoria are characters which strongly suggest a close relationship with the Uredinales. Indeed the main features which would tend to exclude the genus from the rusts are the absence of teliospores and the formation of the basidia from the terminal cells of branched external hyphae rather than in compact sori. Spore forms in the rusts may form on external hyphae as in the genera *Dasyspora, Edythea* and *Desmella*. Tropical rusts are known in which there is no cessation of development from the spore initial to the mature basidium as in *Chrysocyclus* (= *Holwayella*).

It is perhaps unimportant whether one considers *Herpobasidium* a member of the Auriculariales or a simplified form of the Uredinales. In any case it serves to emphasize the probable close relationship between the two groups. If this relationship is a real one it is to be expected that forms will be encountered which could be placed in either group. The possibility that the rust line is a basic one from which the Auriculariales, and perhaps other Basidiomycetes as well, have been derived through simplification and, in many cases, in the loss of the parasitic habit, should not be overlooked.

COMPARISON WITH MICROCYCLIC RUSTS

In any case the fungus, *Herpobasidium filicinum*, invites comparison with the simplified microcyclic rusts particularly since this species develops consistently a two-celled basidium and shows an aberrant nuclear history. In the Uredinales it is only in the Micro- and Endo-forms that species are known which have these peculiarities. The nuclear history in the long cycled rusts, in all the genera in which it has been studied, is remarkably uniform in its essential features.

The variations which are known in the nuclear history in the Endo-forms have been reviewed by the Moreaus (**1919**) and by Dodge and Gaiser (**1926**) and more recently for both Endo- and

Micro-forms by Jackson (**1931**). For the purposes of the discussion which is to follow, it seems worthwhile to summarize briefly with the aid of a condensed diagram (FIG. 2) the types of variation which are known to exist. (Literature references except recent

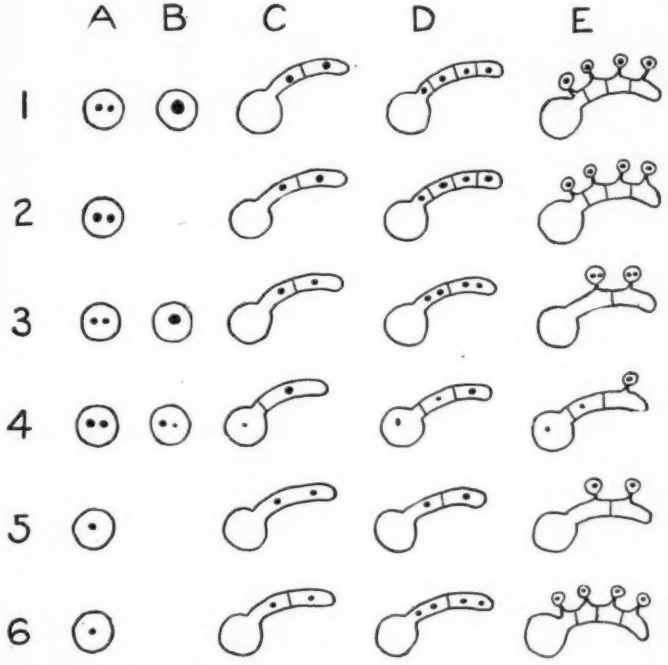

FIG. 2. Diagrams illustrating the nuclear sequence in the six variations known to occur in microcyclic rusts. *A*, condition in the later mycelium and young teliospore; *B*, fusion of nuclei where present; *C*, *D*, *E*, steps in the development of the basidium with nuclear condition indicated.

ones are omitted. For these the reader is referred to the papers cited above.) Six distinct variations have been described. The majority of these are known from studies of the Endo-forms. While many Micro-forms have been examined for the initiation of the binucleate phase, very few species have been studied as to the nuclear detail of the germination of the teliospores.

The six variations are as follows:

1. The mycelium is at first uninucleate, becoming binucleate in connection with the development of the sorus plexus. A fusion of the two nuclei occurs in the young teliospore or aeciospore. Meiosis follows, resulting in four nuclei and a four celled basidium and uninucleate basidiospores. Ex. *Puccinia Malvacearum* Bert., *Endophyllum Sempervivi* (A. & S.) DeBy., *Gymnoconia nitens* (Schw.) Kern & Thurst., (according to Kunkel).

2. The mycelium is uninucleate, becoming binucleate. In the young spore (morphologically the aeciospore) no fusion occurs. The two nuclei pass into the developing basidium and each divides once. Septa are laid down between each of the nuclei and the mature basidium is four celled. Four uninucleate basidiospores develop. Ex. *Gymnoconia nitens* (Schw.) Kern & Thurst. (according to Dodge), *Endophyllum Euphorbiae-sylvaticae* (DC.) Wint.

3. The mycelium is binucleate throughout. The nuclei fuse in the young teliospore. In the developing basidium a septum is laid down after the first meiotic division. No septum is formed following the second division. The mature basidium is two celled, each basidiospore receiving two nuclei, the product of the second meiotic division. Ex. *Puccinia Arenariae* (Schum.) Wint., (Lindfors, **1924**), *P. Anemones-virginianae* and *P. Heucherae* (Lehmann, ined.)

4. The mycelium is at first uninucleate, becoming binucleate. The young teliospore is binucleate but no fusion occurs. One of the two nuclei degenerates. The remaining nucleus passes into the promycelium and is isolated by a cross wall. It then divides once. A cross wall is laid down between the daughter nuclei. The mature basidium is two celled but a basidiospore is formed only from the upper cell, the nucleus in the lower cell degenerating. Ex. *Endophyllum Valerianae-tuberosae* R. Maire.

5. The mycelium throughout is uninucleate as well as the young teliospore. In the basidium the single nucleus divides once and a septum is laid down between the resulting nuclei. The mature basidium is two celled, the basidiospores uninucleate. Ex. *Uromyces Rudbeckiae* Diet. & Holw., *Endophyllum Centranthi-rubri* Poir., *Gymnoconia nitens* (Schw.) Kern & Thurst.

6. The mycelium is uninucleate throughout, the nucleus of the young teliospore passes into the basidium and divides twice. Septa are laid down between the nuclei. The mature basidium is four cell and the basidiospores uninucleate. Ex. *Endophyllum uninucleatum* Moreau. Dodge (**1929**) has suggested that the nuclei in this form as compared with those of *E. Euphorbiae-sylvaticae* are diploid. If so, this may be correlated with the fact that a four celled basidium is formed rather than a two celled one as in other uninucleate forms.

The present study of the nuclear history of *Herpobasidium filicinum* adds another variation to this series. The mycelium, so far as observed, is binucleate. The nuclei fuse in the young basidium and the fusion nucleus divides once. A septum is laid down between the daughter nuclei and the mature basidium is two celled. The products of the first division pass into the basidiospores. The second division does not occur in the basidium and has not been observed. It seems reasonable to assume, however, that the first division of the nucleus occurring at the germination of the basidiospore represents this division and it is probable that the dicaryon initiates in this manner and that the mycelium is binucleate throughout. If this surmise is correct, then the method is comparable to that of *Puccinia Arenariae*, differing from that species in that the second division is delayed till the spore germinates.

It is of interest to speculate as to how these variations may have originated and what their significance may be.

The evidence that short cycled rusts have originated from long cycled forms through reduction is now generally accepted by most students of the group. Stated briefly the origin of the two types of microcyclic forms from the Eu-forms may occur as follows. In the Micro-forms the teliospore (the normal position of fusion of the dicaryon) appears in place of the usual first spore form—the aeciospore. In the typical Endo-forms the position of the fusion of the nuclei is moved ahead to the first spore form (the morphological aeciospore) which then germinates with a basidium (Jackson **1931**).

If this explanation of the origin of microcyclic rusts from those of longer cycle is correct, then such forms are in the nature of life

cycle mutants derived through simplification from the long cycled forms. It is not necessary to assume that the long cycled form should disappear. The number of microcyclic species which may be "correlated" with the parent macrocyclic forms from which they are presumably derived is evidence that the two may continue to exist simultaneously. Since a given parent long cycled form may in all probability throw off life cycle mutants repeatedly, it follows that what is known as a species among short cycled forms may not have had any one time or place of origin. If this reasoning is sound, and assuming that the appearance of homothallism may be correlated in many forms with this process of short cycling, it does not seem surprising that variations from the nuclear history such as is typical of the parent long cycled forms, will be found in the resulting short cycled derivatives. That variations have occurred in the same "species" is indicated by the several forms of *Gymnoconia nitens* described by Dodge (**1924**) and Dodge and Gaiser (**1926**), all of which are traceable in origin to *Gymnoconia interstitialis*.

HOMOTHALLISM AND ITS SIGNIFICANCE

In the development of many of the short cycled forms from those of longer cycle, a change other than in life cycle has occurred, namely the appearance of homothallism. While it might be argued that insufficient facts are available to justify the statement, I venture the repetition of an opinion previously expressed (Jackson **1931**) that heterothallism is a primitive character in the group. If this were not so it is difficult to account for the progressive evolution in the group and the development of the large number of species of diverse form which are now known. After all, the phenomenon which we label "heterothallism" in the fungi is essentially a provision for hybridity. It does not matter whether the "difference" implied in the term is a sexual one or is a genetic one due to factors insuring interfertility, the result is heterozygosity. The sexual process in the long cycled rusts combined with the provision for interfertility and even the greatly simplified process in the heterothallic mushrooms and related forms, is just as effective genetically as in groups having highly developed sexual structures.

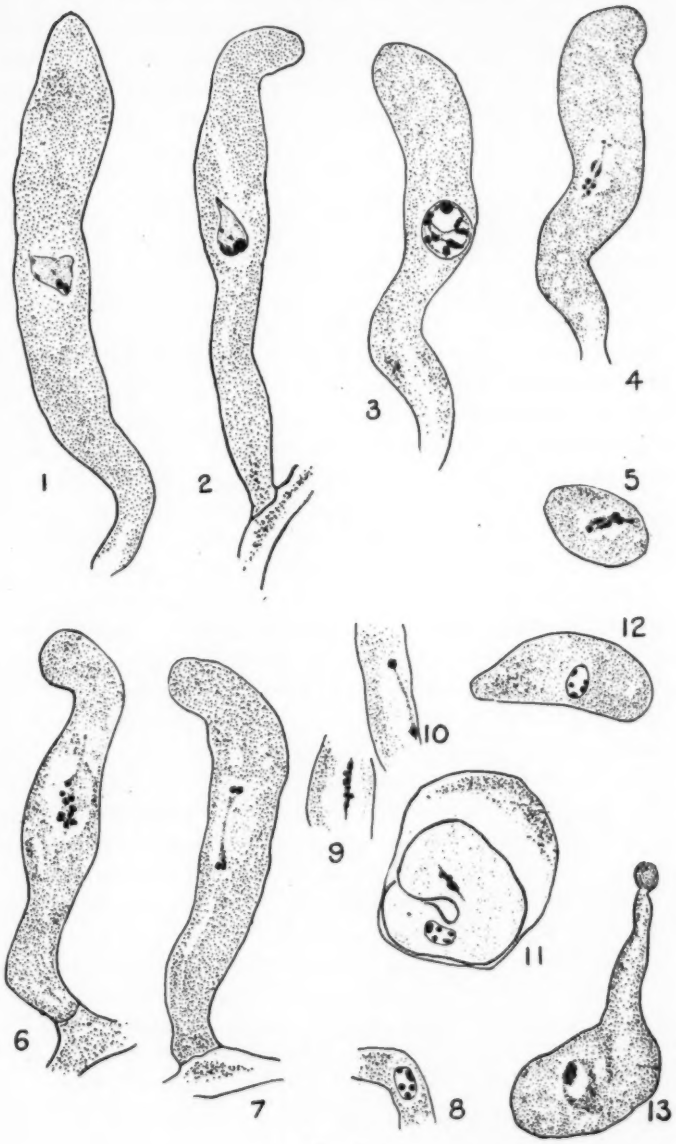

FIG. 3

The absence or loss of this provision for interfertility results in the phenomenon called homothallism.[4] Typically in the rusts and higher Basidiomycetes a form is homothallic when the full life cycle is carried out from a single uninucleate basidiospore. It seems probable that the great majority of microcyclic forms in the rusts will prove to be homothallic. In the case of *Puccinia Malvacearum,* Ashworth (**1931**) has shown experimentally that the full cycle is carried out from a single basidiospore which is at first uninucleate. From the cytological study of Allen (**1933**), Ashworth (1931) and earlier workers, we know the nuclear cycle in some detail. While experimental results are lacking in other short cycled forms, there is considerable evidence that homothallism is a common situation. The majority of species of Micro-*Puccinia* and *Uromyces* lack spermogonia. In many of these which have been studied cytologically, no uninucleate mycelium has been found.

Microcyclic species in which spermogonia are retained may well be either heterothallic or homothallic. Experimental work to determine the facts in individual species is greatly needed. The presence of spermogonia and spermatia, however, should not be considered indisputable evidence that the species is heterothallic. It is quite probable that in some species spermatia may be formed but are no longer functional. *Endophyllum Euphorbiae-sylvaticae* and *Gymnoconia nitens* (the form with a four celled basidium studied by Dodge and Gaiser) are known to have spermogonia, the nuclei, however, do not unite previous to the development of the basidium. Such a situation strongly suggests homothallism. It is difficult to conceive of the uninucleate forms being other than homothallic, yet *Endophyllum Centranthi-rubri* and one of the uninucleate strains of *Gymnoconia nitens* are known to develop spermogonia.

Whatever may be the situation in other forms, we know from the work of Miss Ashworth (**1931**) that *Puccinia Malvacearum* is

[4] Homothallism in the Basidiomycetes, at least in those species which complete the life cycle from a uninucleate basidiospore, should not be compared with the very special type of homothallism found in such four spored Ascomycetes as *Neurospora tetrasperma, Pleurage anserina* and *Gelasinospora tetrasperma* in which two nuclei of different genetic constitution are regularly included in each spore.

homothallic. In this species the basidiospore is uninucleate. This nucleus is the product of a meiotic division (Allen, **1933**). Upon infection a mycelium develops which is at first uninucleate. During the development of the sorus plexus binucleate cells appear. Ashworth (**1931**) has made some observations on the origin of these. Whether these binucleate cells arise from nuclear migration or from a failure of the septa to form is not essential to the present discussion. The important thing to appreciate is that this does not occur just at one place but is a multiple affair. A large number of binucleate cells appear at various points in the sorus plexus initiating a number of dicaryophytic threads, each of which culminates in the formation of one or more teliospores. The nuclei which associate and which finally fuse in the teliospore cells are the products, through successive mitoses, of the original basiodiospore nucleus and are hence homozygous. In such a form one may well ask what is accomplished through fusion and the meiotic process which follows other than the reduction of chromosomes? Barring gene mutations and other possible abnormalities the two sets of chromosomes which come together in the fusion nucleus are identical.

If, then, in such a form as *Puccinia Malvacearum* homothallism results in a homozygous condition and if the nuclei of the dicaryon are essentially sister nuclei, why does a dicaryon develop at all? Having developed, why the fusion in the teliospore? That such a fusion is not essential is illustrated in *Endophyllum Euphorbiae-sylvaticae* and *Gymnoconia nitens*. The nuclei having fused, it is not difficult to account for the appearance of a four celled basidium in *P. Malvacearum*, since the four celled nature of the basidium is correlated with the necessity of meiotic divisions, but why should a four celled basidium develop in *E. Euphorbiae-sylvaticae* and *Gymnoconia nitens* where the nuclei have not fused and no reduction division is necessary? In the uninucleate forms why is a two celled basidium formed in some species and a four celled basidium in others? Why is a basidium formed at all in uninucleate forms?

If one accepts the explanation of the origin of short cycled forms given above, and if this explanation is considered in connection with the genetical implications of the appearance of homothallism

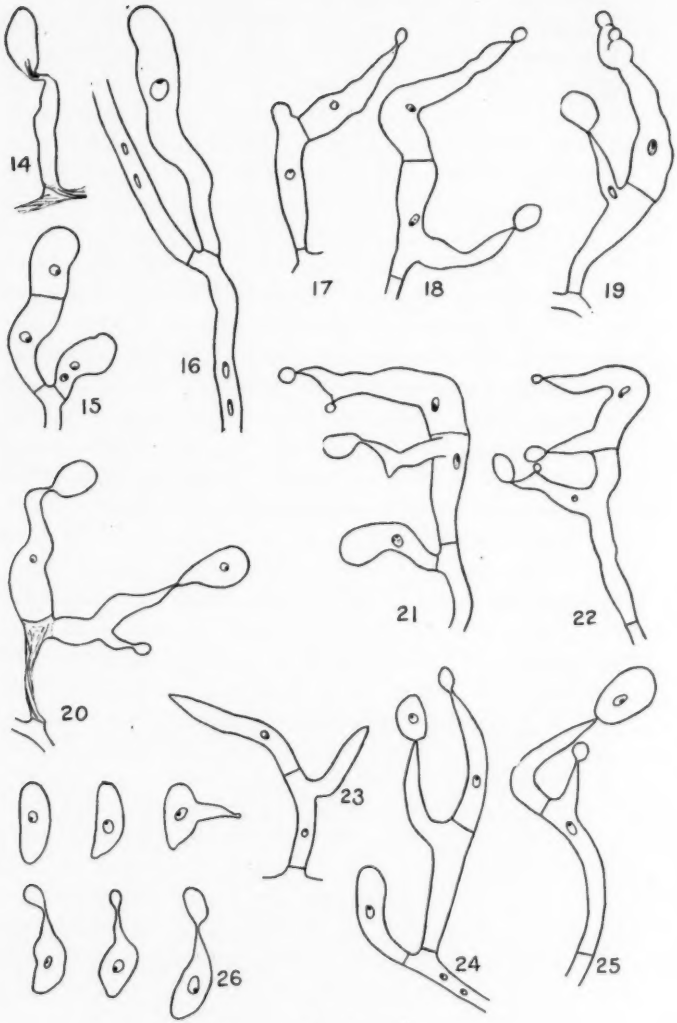

FIG. 4

in such forms, the answer to the questions raised above seems obvious. Since their origin is from long cycled heterothallic species in which a regular nuclear sequence has long become established, it is to be expected that this nuclear sequence will be retained in whole or in part in the short cycled derivatives. Should short cycled forms be developed which remained heterothallic one would expect the nuclear sequence to be the same as in the long cycled forms except that the whole process would be accomplished in one thallus. Should the appearance of homothallism be correlated with the process of short cycling then it might be expected that various modifications of the normal nuclear sequence would occur. A dicaryon might fail to develop resulting in uninucleate forms. If a dicaryon is retained it would have an entirely different origin than in heterothallic forms and the two nuclei would be genetically alike. Having formed the two nuclei might or might not fuse.

In brief, the variations which are known in the nuclear process in microcyclic rusts may be explained on the basis of phylogenetic habit, correlated with the appearance of homothallism. The normal nuclear sequence of the parent long cycled heterothallic species loses its genetic significance when the shortened cycle may be carried out through the divisions of one nucleus and for this reason variations occur.

Where any variation of the normal process of the long cycled forms appears in the derived microcyclic forms it may be considered as indicative that the species is homothallic. The types of variations which are already known furnish an interesting and significant series in the gradual reduction of the basidium. It is quite to be expected that microcyclic forms will be discovered which no longer produce a basidium. These are to be looked for especially in the Endo-forms where the spore is a disseminating spore. In a uninucleate Endo-form the ultimate reduction would be the loss of the basidium in which case the spore would be expected to germinate with a germ tube. It is possible that the uninucleate forms of *Aecidium punctatum* Pers. and *A. leucospermum* DC. studied by Kursanov (**1922**) and some of the species of *Peridermum*, obviously derived from *Cronartium*, which are known to repeat themselves on *Pinus*, are of this Endo-type.

To the writer there seems no reason why a similar interpretation

may not apply to homothallic basidiomycetes in general. In *Coprinus sterquilinus* Fries, for example, the full life cycle is carried out from a single basidiospore which receives one of the four nuclei from the second meiotic division in the basidium (Sass, **1935**). The spore regularly becomes binucleate before germination. On germination a multinucleate phase prevails for a time but soon a typical dicaryophytic condition develops in which there are regularly two nuclei which divide through the agency of clamp connections (Brunswik, **1924**; Buller, **1931**). I see no necessity to assume that because a dicaryon develops and the nuclei divide through the agency of clamp connections that this is evidence for the assumption that the two nuclei are different. They are the product of the divisions of a single nucleus. To assume a difference implies a segregation of characters at some point other than in the reduction divisions (Sass, **1929**, *Text fig. 4*). Such an assumption is unnecessary and has no experimental basis. Harder's (**1926**) dissection experiments with this species in which a mycelium was regenerated from the temporarily uninucleate penultimate cell of a hyphal tip proves nothing in support of a difference between the two nuclei. *Coprinus sterquilinus* may be assumed to have been derived from a heterothallic species, a race of which became "self fertile." The development of a dicaryon and of clamps, the fusion in the basidium and the reduction division are all explainable on the basis of habit derived from the parental form.

The proper understanding of homothallism in all its aspects in all groups of the fungi is highly important in connection with any consideration of relationships. If heterothallism is basic and primitive and homothallism derived, then homothallic forms may be expected to show simplification, not only with reference to the nuclear history but also in morphology, particularly in the loss or modification of structures having to do with sexuality and interfertility. Such considerations are likely to prove of great importance in the development of our knowledge of relationships and interrelationships, not only in the Basidiomycetes but perhaps more particularly in the Ascomycetes.

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EXPLANATION OF FIGS. 3 AND 4

FIG. 3. 1, fusion nucleus of basidium showing two nucleoli; 2, fusion nucleus with one large nucleolus; 3, late prophase showing four bivalent chromosomes; 4, early metaphase showing four chromosomes and nucleolus; 5,

section oblique to basidium showing nucleus in metaphase with four chromosomes and nucleolus with one central body in view; 6, a division in anaphase; 7, a division in telophase; 8, prophase of division in vegetative mycelium; 9, the same in anaphase; 10, the same in telophase; 11, the two nuclei in a haustorial cell, the lower in prophase, the upper in metaphase, showing two long and two short chromosomes; 12, basidiospore with resting nucleus; 13, same preparing to develop secondary spore. Drawn by Dr. Elizabeth Astrom Thompson.

FIG. 4. 14, nucleus passing through tip of sterigma into spore; 15, two basidia, lower one before fusion of nuclei, the other after the fusion nucleus has divided; 16, binucleate external mycelium and young basidium with fusion nucleus; 17, 18, 19, basidia forming spores, each cell uninucleate; 20, basidium in which lower cell is collapsed, the cytoplasm confined to the sterigma and the nucleus in the spore; 21, 22, basidia showing abnormal attempts to form more than one spore; in figure 22 the upper cell is developing two sterigmata; 23, basidium; 24, 25, basidia showing the nucleus of one cell in the spore; in each case the cytoplasm is clear; no evidence of abortive nuclei; 26, spores, each uninucleate, four of them showing the development of secondary spores.

GASTERELLA, A NEW UNILOCULATE GASTEROMYCETE[1]

S. M. Zeller and Leva B. Walker

(with 13 figures)

In July, 1932, a tiny, whitish, globular fungus was discovered by Dr. Abigail K. Blake on the surface of wet woodland soil in a pan protected by a glass plate sealed with vaseline. The pan of earth was being used in the greenhouse at the University of Nebraska in a series of experiments with the seed germination of prairie plants. The little fungus developed on the moisture-saturated soil along with diatoms and blue-green algae. The fructifications of this fungus for which we have chosen the generic name, *Gasterella,* were depressed globose, maturing to about 200–700 μ in diameter. They thickly dotted the surface of the soil to which they were attached below by delicate hyphae. The older mycelial hyphae were more or less gelatinous and often seemingly encrusted. As the basidiocarps matured they changed from pure white to ashy gray or even black in old age. The fruiting bodies were very abundant, new ones being constantly formed, until following a very hot day when they all died down. A new crop developed the next week when cooler weather prevailed. These matured within 3 or 4 days of their first appearance. Another hot spell killed the second crop of fructifications of the fungus, and in spite of the fact that the soil has been kept moist during the entire period since, no further growth has appeared.[2]

[1] Published as Technical Paper No. 234 with the approval of the Director of the Oregon Agricultural Experiment Station. Contribution from the Botany departments of Oregon State College and the University of Nebraska, coöperating.

[2] Since the completion of this manuscript an abundance of materials of *Gasterella lutophila* has been secured on fresh loess soil from near Peru, Nebraska, which was secured through the kindness of Dr. J. M. Winter of the Peru State Teachers College. Two lots of soil were sent, the first December 12, 1934, and the second February 16, 1935. The soil in both cases was placed in containers, saturated, and closely covered. In each case an abundance of fructifications appeared in about three weeks. This seems to indicate that the fungus is very abundant in such soil.

The surface of the fructifications is dry, cottony or innately fibrillose. The peridium is about 20 μ thick, made up of a few loosely woven hyphae mostly parallel to the surface, evidently the fundamental tissue of the earliest primordial stages.

The gleba is as simple as represented in *Protogaster*,[3] consisting of one cavity, the wall of which is adorned by a smooth hymenial layer of clavate basidia with here and there a few capitate, clavate cystidia with dark, roughly-encrusted heads. The basidia are 2–4-spored, the latter predominant. Basidia for the most part are to be found in young fructifications. They soon collapse and disappear at maturity.

The spores are rounded below, broadly citriform with a broad apiculus. The epispore is very dark brown, quite uniformly verrucose except the apiculus which is somewhat lighter in color and almost smoothly rounded. The spores measure 10–12 $\times$ 12–14 μ.

Many basidiocarps representing later developmental stages were embedded and prepared slides of over 50 were studied.[4] Three such stages are represented by diagrammatic drawings (FIG. 1, 2, AND 9). The nuclear history in the basidium is quite the rule as found in many of the more highly developed Gasteromycetes. The cells of the subhymenial hyphae and the erect hyphal terminals in the hymenial fundaments are binucleate. In the developing holobasidium the dikaryon fuses to form a large diploid nucleus (FIG. 3). (The staining did not bring out the chromosomes.) The diploid nucleus now passes through at least two stages of division so that the young basidium beginning the growth of sterigmatal protuberances is at least four nucleate. In some cases, however, in the stages of development represented by figures 4, 5, and 6, nuclei were unmistakable in the spores while four were yet to be seen in the basidium. This indicates the probable third step in division of the diploid nucleus, resulting in eight nuclei, four of which doubtless degenerate in the basidium, one migrating

[3] Zeller, S. M., *Protogaster*, representing a new order of the Gasteromycetes. Ann. Missouri Bot. Gard. **21**: 231–249. *illus.* 1934.

[4] Materials were fixed in formal-acetic-alcohol (50 per cent alcohol 93 cc., neutral formalin 6 cc., glacial acetic acid 1 cc.) and in Bouin's fluid to which one part of urea had been added. The sectioned material was stained with Heidenhain's iron-alum-haematoxylin after which a counter stain of orange G in clove oil was added.

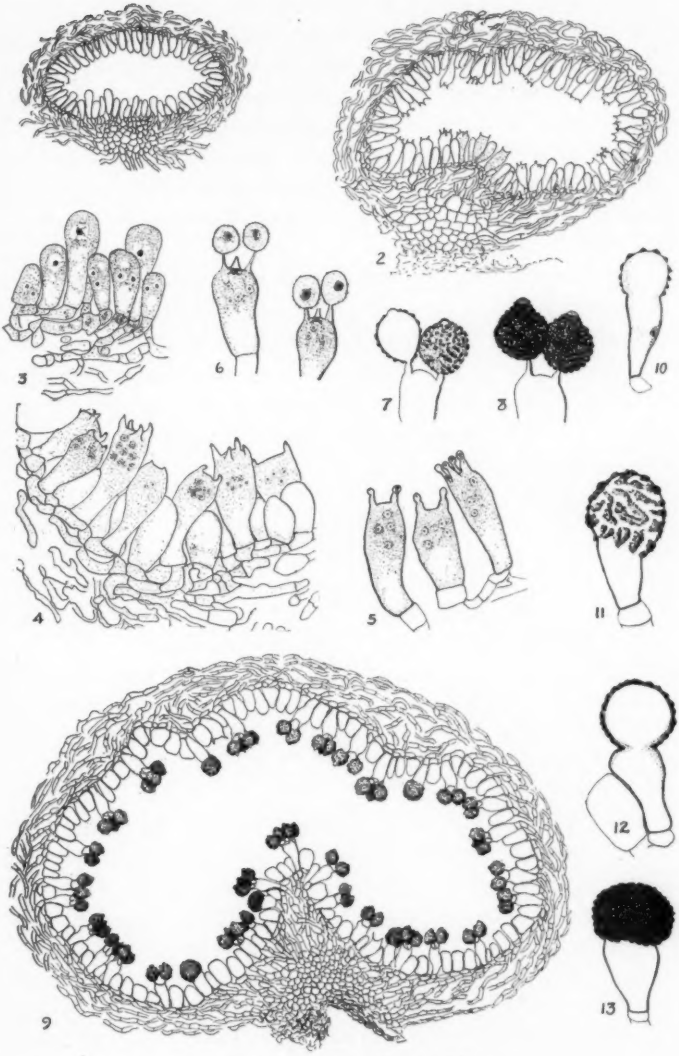

FIG. 1–13. *Gasterella lutophila.*

to each spore. In fact, in three cases eight very small nuclei were seen in young basidia at such a stage as represented by figure 4. Just what happens in the case of 2- and 3-spored basidia has not been observed, but all the spores seem to be uninucleate, a condition different from that in most other Gasteromycetes, except a few cases such as in *Geaster velutinus*[5] and *Secotium agaricoides*.[6] Where the dikaryon condition in the mycelium begins must for the time be left to conjecture since we have observed only binucleate, secondary mycelium.

The spores are borne symmetrically on the sterigmata as is true in other Gasteromycetes. The development of the basidia of a given basidiocarp seems to be quite irregular, so that some basidia are more advanced than others. In such cases it is impossible to distinguish primordial basidia from paraphyses. It appears, however, from the examination of mature sporocarps where all basidia have evidently matured, there still remains quite a representation of sterile cells, paraphyses.

As stated above, besides the paraphyses there are other scattering sterile cells in the hymenium, namely, cystidia. These project above the paraphyses and are up to 17 μ in diameter. One might confuse the heads of these cystidia with the basidiospores because of their color and markings, if it were not for their shape, size, and content. They are borne at the ends of basidium-like cells but are not abstricted from the basal cell, as shown in figures 10 and 12. These median sections show these spore-like heads to open into the stalk-cell and to be almost devoid of content.

The cystidia may become significant as an aid in the phylogenetic relationships of *Gasterella* and the Gasteromycetes as a class. These organs are strikingly common in many of the Thelephoraceae (*sensu latiore*) on the one hand, and the Agaricaceae on the other, but they have rarely been mentioned as characteristic of the Gasteromycetes. In *Gauteria graveolens* Vitt. cystidia are conspicuous while in *G. gautierioides* (Lloyd) Zeller & Dodge and *G. morchelliformis* Vitt. they are less prominent. In these 3 spe-

[5] Cunningham, G. H. The development of *Geaster velutinus*. Trans. Brit. Myc. Soc. **12**: 12–20. *illus.* 1927.

[6] Conrad, H. S. The structure and development of *Secotium agaricoides*. Mycologia **7**: 94–104. *illus.* 1915.

cies of *Gauteria* the cystidia are smooth and quite thin-walled as in many of the Agaricaceae while those of *Gasterella* are more nearly like those in some genera of the Thelophoraceae and some brown-spored agarics like *Pholiota*. They are very similar in form to those of *Collybia conigena* as illustrated by Patouillard.[7] The cystidia of *Gasterella* seem almost like one-spored basidia which have lost their reproductive function, or if the spore-like head were fully abstricted and viable it might be interpreted as a chlamydospore.

Contrary to the condition in *Protogaster*, the place of attachment of the basidiocarp of *Gasterella* is always not only discernible but also definite. During the development of the sporocarp there is formed at the place of attachment a sterile base of pseudoparenchyma. This develops upward into the glebal cavity forming at maturity a definite conical protuberance (FIG. 9). So far as our present knowledge of the Gasteromycetes has been evolved this represents the simplest persistent form of sterile-tissue development subsequent to the fundament of the primordial sporocarp. It is therefore perhaps the most primitive of such sterile tissues yet discovered.

Because of the uniloculate gleba at maturity this genus rightfully belongs in the Protogastrales (Zeller, *l. c.*), the description of which should be amended to include forms with "*simple* sterile base" which is also very rarely present in *Protogaster*. *Gasterella*, however, conforms to an entirely different series of genera (so far as spore markings are concerned) than that represented by the smooth-spored genus *Protogaster*, and therefore should doubtless be referred to a new family, but we prefer now to include it in the Protogastraceae (Zeller, *l. c.*). There is no definite invagination of the locular walls in *Gasterella*.

The shape and markings of the spores in *Gasterella* place the genus definitely in the developmental line leading to *Hymenogaster*, and it is significant that certain species of *Hymenogaster* recapitulate in their early development a stage represented by the sporocarp of *Gasterella*. The morphological studies by Reh-

[7] Patouillard, N. Les Hyménomycètes d'Europe. 1887. (See *pl. 2, f. 13.*)

steiner [8] are convincing evidence of a direct linkage with *Hymenogaster* when viewed in the light of the development of *Gasterella*. Rehsteiner studied the development of *Hymenogaster verrucosus* Bucholtz (*H. Rehsteineri*), in the young stages of which a single locule (cavity) becomes the fundament of the gleba. In these early stages just above the place of attachment of the basidiocarp the sterile base becomes quite prominent and at these stages the development of the sporocarp of *H. verrucosus* recapitulates essentially the stage of *Gasterella* shown in figure 1. While in *Gasterella* there is no essential morphological change from this stage to maturity, in *Hymenogaster* the tramal plates emerge downward and basipetally from just beneath the upper part of the peridium as do the primordial lamellae in the single annular cavity of certain angiocarpous agarics. The same type of basipetal development in *Hymenogaster* reaches an advanced stage in species where cavities form above and continuously encroach upon the sterile tissues below until no sterile base remains at maturity. It appears therefore that *Gasterella* of the Protogastrales has its closest affinities with *Hymenogaster* through such primitive species of the genus as represented by *H. verrucosus*, and that *Hymenogaster* has a natural origin from *Gasterella* or *Gasterella*-like forms.

Gasterella Zeller & Walker, gen. nov.

Fructificationes minutae, subsphaericae; peridium simplex primordiale contextum, indehiscens; basis sterilis pulvinata vel conica, pseudoparenchymatica; gleba uniloculata; hymenium laeve; sporae brunneae, citriformes, apiculatae, verrucosae.

Fructifications small, subspherical; *peridium* of simple fundamental tissue, indehescent; *sterile base* pulvinate to broadly conical, pseudoparenchymatous; *gleba* unilocular; *hymenium* smooth; *spores* brown, citriform, apiculate, verrucose.

Gasterella lutophila Zeller & Walker, sp. nov.

Fructificationes oblate sphaeroideae, 200–700 μ diametro, superficie arida, alba vel pallide brunneo-grisea, byssoidea vel innato-fibrillosa; basis sterilis pulvinata vel subconica, pseudoparenchymatica; peridium circa 20 μ crassum, simplex, ex hyphis hyalinis tenuibus laxe implicatis; gleba uniloculata, brunnea, locellus maturitate vacuus; hymenium laeve; basidia hyalina,

[8] Rehsteiner, H. Beiträge Zur Entwicklungsgeschichte der Fruchtkörper einiger Gasteromyceten. Bot. Zeit. **50**: 764–771. *pl. 10, f. 1–6.* 1892.

clavata 2- vel 4-spora, sterigmatibus brevibus; cystidiis capitato-clavatis, capitulo atro-brunneo verrucoso; sporae nigro-brunneae late citriformes, apiculo lato, laevi, episporio verrucoso, 10–12 × 12–14 μ.

Gregaria, ad terram uvidam in viridarium, Lincoln, Nebraska..

Type material in Walker Herbarium and Zeller Herbarium.

Fructifications depressed globose, 200–700 μ in diameter, white at first becoming light brownish drab, surface dry, cottony to innate fibrillose; *sterile base* pulvinate to subconical, pseudoparenchymatous; *peridium* of a simple layer of loosely interwoven hyphae mostly parallel with the surface, hyaline, about 20 μ thick; *gleba* uniloculate, brown, *cavity* empty; *hymenium* smooth; *basidia* clavate, 2–4-spored (mostly 4), soon evanescent; cystidia capitate-clavate, the head dark brown, verrucose like the spores; *spores* broadly citriform, with a broad apiculus, epispore dark brown, uniformly verrucose except the lighter colored apiculus, 10–12 × 12–14 μ.

On the surface of damp earth in a pan, in the greenhouse. Lincoln, Nebraska. July.

EXPLANATION OF FIGURES

Illustrating *Gasterella lutophila* Zeller & Walker: 1, diagrammatic median section of a young fructification showing the fundamental tissue of the peridium, the pseudoparenchyma of the sterile base, and immature basidia and paraphyses, × 250; 2, this shows a little more advanced stage than that represented in figure 1, very immature spores developing on the sterigmata, the sterile base slightly more prominent than in figure 1, × 250; 3, shows the nuclear condition of the stage of development represented by figure 1, × 750; 4, shows a magnified section of the hymenium from the fructification illustrated in figure 2, meiosis having taken place in the nuclei, × 750; 5, three basidia from the same fructification as those shown in figure 4 but advanced enough to show the beginning of spore formation and the migration of the nucleus into the spore, × 750; 6, two basidia showing two of four immature spores; in this stage the spores are definitely uninucleate and the exospore is developing rough markings, × 750; 7, basidium showing two of four immature spores (one in section) with *Hymenogaster*-like markings in the exospore, × 750; 8, two mature, broadly rounded, broadly apiculate citriform spores showing the *Hymenogaster*-like markings, × 750; 9, diagrammatic section of a mature fructification (note the peg-like, conical, sterile base on a foundation of pseudoparenchyma), × 250; 10 and 11, immature capitate cystidia, showing the encrusted head, figure 10 a median section, × 750; 12 and 13, mature capitate cystidia, showing the dark roughened head markings similar to those of the spores, figure 12 a median section, × 750.

DIAPORTHE PHASEOLORUM ON PEPPER FRUITS[1]

C. M. TUCKER

(WITH 11 FIGURES)

In September, 1932, and again in 1933, mature and green fruits of pepper (*Capsicum annuum*) in a garden in Columbia, Missouri, were attacked by a fungus which causes a black, leathery type of rot extending more rapidly longitudinally than laterally in the tissue, and producing long, rather narrow lesions. In old lesions the dead tissue becomes dry and bleached (FIG. 1). Infection frequently appears to have originated at the calyx end. The lesions resemble, slightly, those resulting from infection by the anthracnose fungus, *Glomerella cingulata,* but differ in the shape and color of the infected areas and in the pliable, leathery condition of invaded tissue.

On the surface of infected areas appear minute pustulate swellings, which finally break through the epidermis. These are small, subglobose, erumpent, ostiolate fruiting bodies, the pycnidia, usually 200–300 microns in diameter, and contain two types of spores characteristic of the form genus *Phomopsis.* The condia or alpha spores are unicellular, ovoid to oblong-fusoid, hyaline, 2-guttulate, 7.2–9.2 × 2.2–3.2 microns, averaging 7.9 × 2.7 microns. The alpha spores develop first and germinate readily. The beta spores develop later and rarely germinate.

An examination of the literature reveals no previous record of a *Phomopsis* on pepper in America. Magnaghi (**4**) in 1902 described *Phoma Capsici,* on fruits in Italy, with conidia 7–9 × 2–3 microns and basidia (stylospores) 20–22 microns long. These measurements are nearly identical with those of our fungus. Bianchi (**2**) in 1911 mentioned *Phoma Capsici* forma *caulicola,* also in Italy, as a new variety, apparently differing from *Phoma Capsici*

[1] Contribution from the Department of Botany, Missouri Agricultural Experiment Station; Journal Series No. 407.

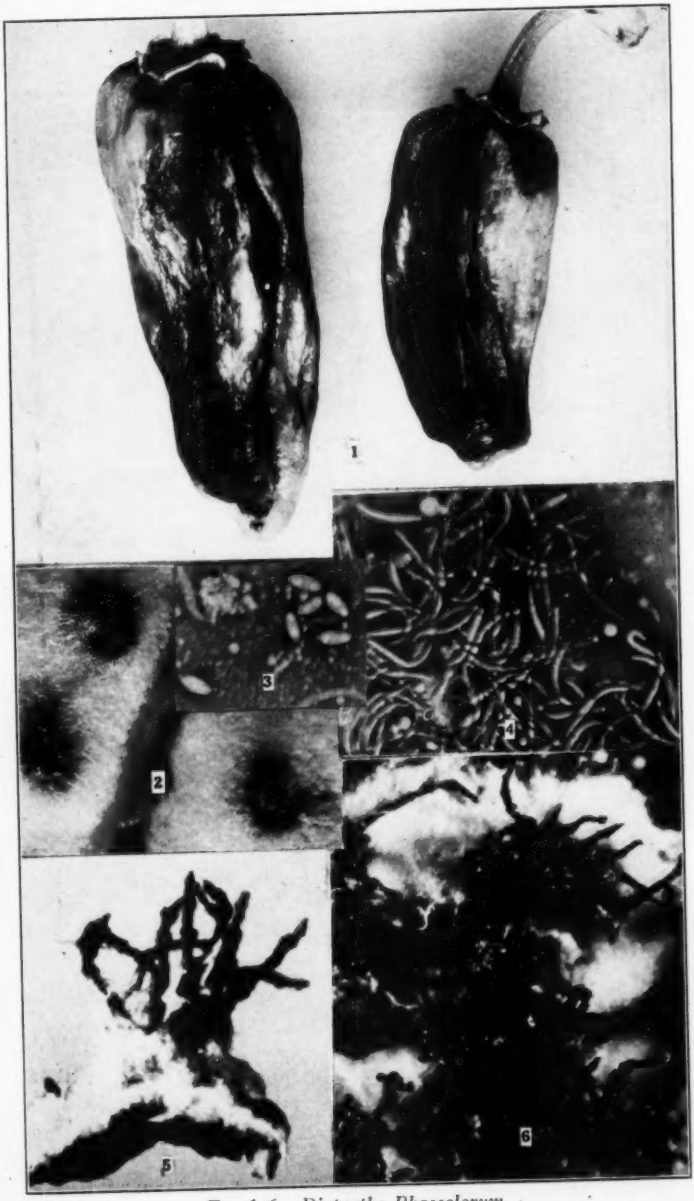

FIG. 1–6. *Diaporthe Phaseolorum.*

only in its occurrence on stems rather than fruits. In 1916 Baker (**1**) wrote that pepper pods dried and hung in strings became badly infected by *Phomopsis Capsici* during periods of wet weather in the Philippine Islands. The new combination, *Phomopsis Capsici*, was published by Saccardo (**6**) in the same year, after examination of Philippine material, although the spores in the pycnidia he examined are described as 5–3 × 2 microns, considerably smaller than those described by Magnaghi. In 1919 Reinking (**5**) reported the same fungus again in the Philippines and Curzi and Barbaini (**3**) in 1927 noted its occurrence again in Italy. These records constitute our knowledge of the distribution of a *Phomopsis* on peppers.

Isolation from the infected fruit tissues yielded a white fungus which grows well on all ordinary agar media. Inoculations of detached, wounded green pepper fruits with mycelium caused a rapid rotting with the development, after 7 days, of pycnidia containing alpha type spores. After 13 days both types of spores were present. Under laboratory conditions the fungus causes a soft, wet rot which spreads over the entire fruit.

On potato dextrose agar the fungus covers the surface with white mycelium. In about 10 days black, carbonaceous pycnidia, much larger than those on pepper fruits, appear scattered singly on the agar (FIG. 2). Young pycnidia contain both conidia and stylospores, but stylospores only can be found in many older ones. In culture the spores are small, the conidia averaging 6.1 × 2.6 microns and the stylospores 14.6 × 1.5 microns (FIG. 3, 4).

In cultures one month old black, carbonaceous stromata, embedded in the agar, cover nearly half of the surface. Immersed in the stromata are the perithecia, usually in clusters, each 150–300 microns in diameter and tipped with a long, sinuous, irregular, carbonaceous beak bearing an ostiole (FIG. 5, 6). The asci are 8-spored, clavate, 34.2–44.1 × 7.2–9.0 microns; average 39.2 × 7.9 microns; the ascus wall is thin and transparent, but thickened at the apex and provided with a refringent plug pierced by a narrow pore (FIG. 11). The ascospores are obliquely uniseriate, fusoid-ellipsoid, 2-celled, constricted at the septum, guttulate, each cell containing 2 guttulae, a larger one near the septum and a smaller one near the apex, 9–11 × 2.5–3.5 microns, average 9.9 × 3.1 microns.

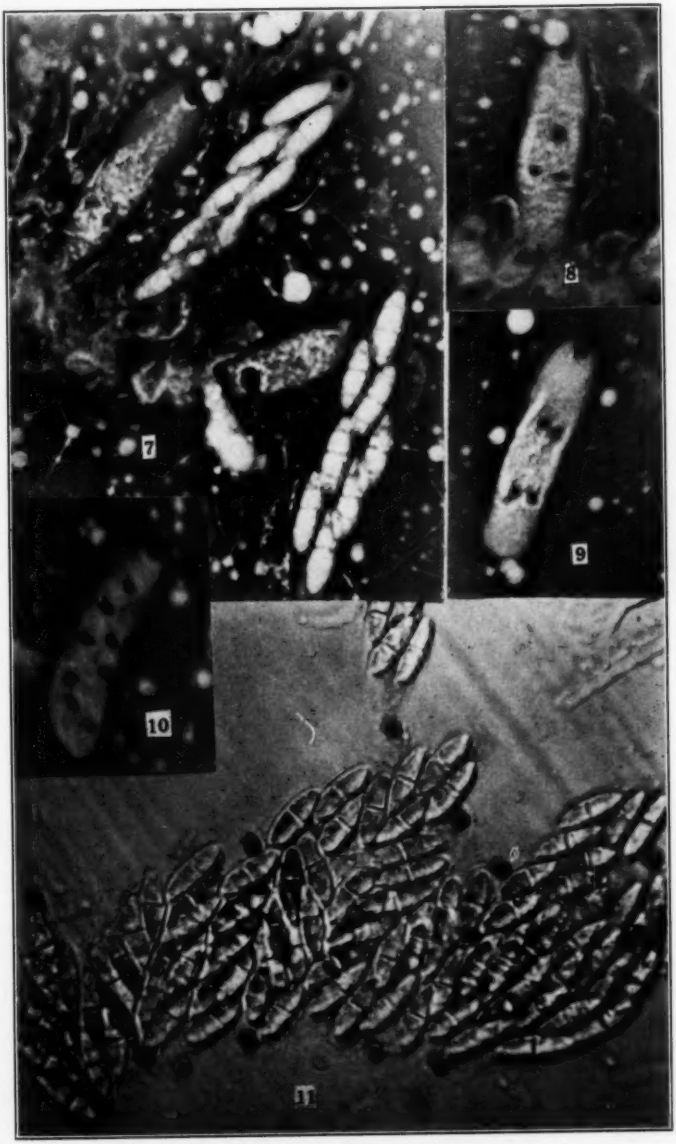

FIG. 7–11. *Diaporthe Phaseolorum.*

Seven single ascospore cultures reproduced the typical asexual and sexual stages, establishing the connection of the forms and proving the homothallic character of the mycelia from single spores, yet admitting the possibility of segregation of sex in the final nuclear division and the existence of plus and minus nuclei in the 2 cells of the spore. No single cell cultures were studied.

The sexual stage is clearly referable to the genus *Diaporthe* and was considered very similar to *D. Batatatis* Hart. & Field. Wehmeyer (**7**) in his recent excellent monograph based on morphologic characters of the genus considers *D. Batatatis* a variety of *D. Phaseolorum* (Cooke & Ellis) Sacc. and a culture of the pepper fungus sent to him was identified as a member of the group he includes in this species. *Phomopsis Capsici* (Magnaghi) Sacc. and *Phoma Capsici* forma *caulicola* Bianchi should probably be included in the list of synonyms.

The pepper isolation is of further interest as convenient material for the demonstration of nuclei in the developing ascus. When immature asci are dried on a slide in a drop of 1 per cent aqueous nigrosin solution the dye penetrates and stains the nuclei. Examination under oil without a cover glass reveals various stages from the fusion nucleus to the delineation of the spores. All stages may often be found among asci from a single perithecium (FIG. 7–10). After the third division the spore walls develop followed by the final division of the nuclei and the development of the septum. The nigrosin does not penetrate and stain the nuclei after the spore walls develop.

The plug embedded in the apex of the ascus is deeply stained. Partial destaining by adding a drop of water to the preparation brings out the plug as a ring with a small pore through the center (FIG. 11). Just how this ring functions, if it does function, as a mechanism for spore discharge, was not observed.

The fungus is maintained in living cultures in our collection and transfers are available to anyone. This easily cultured fungus and the simple, rapid method for demonstrating the nuclei and rings recommend the procedure for class room use.

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EXPLANATION OF FIGURES

Fig. 1, lesions on fruits of *Capsicum annuum* caused by *Diaporthe Phaseolorum* (Cooke & Ellis) Sacc., natural infection; 2, pycnidia (*Phomopsis* stage) of *D. Phaseolorum* from a potato dextrose agar culture 2 weeks old (× 20); 3, alpha conidia produced in culture (× 800); 4, beta conidia produced in culture (× 800); 5, *D. Phaseolorum*, a single stroma bearing clustered beaked perithecia (× 20); 6, stromata and long beaked perithecia; from 6 weeks old potato dextrose agar culture (× 20); 7–10, stages of ascus development from the uninucleate stage through the third nuclear division and the initiation of ascospore delineation (× 900); 11, mature asci stained with nigrosin and partially destained; note the ring-like plug in the apex of each ascus (× 900).

STUDIES IN THE GENUS MYCENA—II [1]

ALEXANDER H. SMITH

(WITH 2 FIGURES)

In this contribution sixteen species are critically discussed and four are proposed as new (*Mycena borealis, M. fagicola, M. Kauffmani,* and *M. quiniaultensis*). Most of the notes were taken from material collected in Michigan, but a collecting trip to Nova Scotia in 1931 and one to the Adirondack Mts. in New York during the season of 1934 contributed much valuable additional information.

It is the writer's purpose in this series of papers to discuss those species or groups of species within the genus which are most difficult to interpret. Only those which have some striking and unusual character are described as new. For all others the collections have been placed in the previously described species which seems to fit the writer's material most accurately.

For a critical discussion of European forms and for a generous exchange of material, the writer is particularly indebted to Mr. A. A. Pearson of England. The collecting trip to the Adirondacks was made possible through the courtesy of Assistant Dean Clyde Leavitt of the Forestry College of Syracuse University, Syracuse, N. Y. Collecting was carried on at the Archer and Anna Wild Life Forest Station near Newcomb, and at the Pack Forest near Warrensburg, N. Y. Because of favorable weather conditions at Warrensburg abundant *Mycena* flora was found, and much valuable information concerning the species described by Peck and Murrill was obtained.

Mycena borealis sp. nov.

Caespitosa vel subcaespitosa; pileus 1–4 cm. latus, obtuse conicus demum campanulatus, umbonatus, fuscus vel griseus, demum pallidus, striatus, subhygrophanus, lubricus vel subviscidus; lamellae adnatae, brevissime angulatim decurrentes, subdistantes vel distantes, venoso-reticulatae, angus-

[1] Papers from the Department of Botany and the Herbarium of the University of Michigan, No. 528.

tae; stipes 3–5 cm. longus, 2–4 mm. crassus, albido-fibrillosus demum glaber, fuscus vel griseus; sporae 9–10 × 4–5 μ, ellipsoidae; basidia tetraspora; cystidia 60–120 × 8–12 μ, fusoido-ventricosa demum cylindrica, apice aspera. —Specimen typicum in Herb. Mich. conservatum, prope Colchester County Nova Scotia lectum, August 27, 1931, A. H. Smith n. 759a.

Pileus 1–4 cm. broad, obtusely conic, becoming campanulate with an obtuse umbo, margin reflexed in age, colors gray with a tint of cinnamon or nearly white, "cinnamon-drab"[2] to "fuscous" on the umbo, fading to pale gray in age, pellucid or sulcate striate with numerous fine striations between the larger ones, subhygrophanous, lubricous to subviscid when wet, pellicle present but separable only in shreds, margin appearing slightly rimose or crenate at times, reflexed in age; lamellate adnate with a tooth, subdistant to distant, spaces between reticulate with vein-like ridges, narrow, white, no flesh tints seen in old specimens; stipe 3–5 cm. × 2–4 mm., beautifully white fibrous when young, glabrous and rather transparent in age, tough, concolorous or paler than the pileus, often compressed, white-strigose at base, gregarious to subcespitose on wood of conifers; spores 9–10 × 4–5 μ, narrowly ellipsoid; basidia four-spored; cystidia abundant, 60–120 μ, often projecting 50–75 μ, 8–12 μ broad, fusoid-ventricose at first, cylindric in age, apex set with numerous fine projections about 2 μ long; sterile cells similar; odor none; taste slightly farinaceous.

Collections of this species from Nova Scotia where it was exceptionally abundant in 1931, from New Brunswick (among Atkinson's unnamed material), from New York by Atkinson, Mains, Smith and members of the Mycological Society of America on the 1934 summer Foray, from Michigan by Mains and Smith, and from Tennessee (alt. 6,000 ft.) by Hesler, are all constant in the characters as described. The species is almost the exact counter part of *M. polygramma* var. *albida* Kauff. in stature and consistency, but differs in the darker color, peculiar cystidia, and habitat on wood of conifers. It is also related to *M. sudora*, but the cystidia readily distinguish it.

Mycena fagicola sp. nov.

Pileus (5) 10–30 mm. latus, convexus, obtuse unbonatus vel planus, glaber, purpureo-rubrus; lamellae adnatae, confertae, angustae vel ventricosae, stramineae, acie atro-purpureae; stipes 2–4 cm. longus, 2–3 mm. crassus, dorsum rubrus, apice aurantius et fibrillosus; fibrillae atropur-

[2] All names of colors within quotation marks are taken from R. Ridgway, Color Standards and Color nomenclature, 1912.

pureae; succus aurantio-sanguineus, non copiosus; sporae 7–9 × (3) 4–5 μ; basidia tetraspora; cystidia 30–40 × 6–10 μ, leves. Specimen typicum in Herb. Mich. conservatum, prope Cross Village Michigan lectum October 7, 1934, A. H. Smith no. *992*.

Pileus (5) 10–30 mm. broad, convex, obtusely umbonate or expanded plane, at times the disk slightly depressed, pruinose at first, glabrous, disk " claret brown " when young, soon " mahogany red " to " Morocco red," in age " bay," margin " Sanford's brown " and becoming " Isabella color," sulcate striate in age, not crenate; flesh buff color, exuding an orange-yellow juice when cut; lamellae moderately close to subcrowded, bluntly adnate, narrow to moderately broad, " chamois " when young, somewhat darker in age, edge near " victoria lake " or " maroon," crenulate or even; stipe 2–4 cm. × 2–3 mm. reddish below, orange-yellow above, scantily fibrillose from " claret brown " fibrils, apex often scabrous and surface colored " claret brown " from the fibrils, purplish brown color ceasing abruptly at the apex, exuding a dull reddish brown or dull orange juice when broken or cut (juice darker in fresh young plants), base rooting somewhat among the leaves; spores 7–9 × 3–4 μ (*935*) 7–9 × 4.5–6 μ (*992*); basidia four-spored; cystidia on edge of gills only, or rare on sides, narrowly lanceolate and smooth, 30–40 × 6–10 μ, content dark red. Gregarious on leaves in beech and beech-hemlock woods. Collections from Warrensburg, N. Y. (*935*) and Cross Village, Mich. (*992*) are in the Univ. of Mich. Herbarium. Collection *13941* of Atkinson is the same and is in the Atkinson Herbarium of Cornell University.

This species is perhaps most closely related to *M. cruenta,* but the yellowish gills with the dark purplish red edge and the fibrils at the apex of the stem easily separate it. *M. sanguinolenta* is a much smaller species with distant gills and a glabrous stipe which is evenly dark reddish brown in color. Atkinson in his notes commented on no. *13941* as being similar to *M. pelianthina.* There is a decided resemblance in stature, but the presence of the darkly colored juice distinguishes *M. fagicola* immediately.

Mycena Kauffmani sp. nov.

Pileus 1–3.5 cm. latus, conicus demum planus vel umbonatus, fuscus, demum sordidus, striatulus; lamellae confertae vel subdistantes, latae, ventricosae, uncinatae vel adnatae, albae, acie brunneae et crenulatae; stipes 1–5 cm. longus, 1–3 mm. crassus, radicatus, rigidus, pruinoso-fibrillosus; fibrillae brunneae; sporae 6–8 × 4–5 μ, late ellipsoideae; cystidia 35–45 × 8–12 μ, clavata vel fusoidea, apice obtusa; corticus pilei cellis pyriformibus vel

obovatis praeditus.—Specimen typicum in Herb. Univ. of Mich. conservatum, prope Dexter Mich. lectum, June 11, 1934, A. H. Smith no. *13*.

Pileus 1–3.5 cm. broad, conic, becoming plane or slightly umbonate, "fuscous-black" to "fuscous" on the umbo when young, fading to "mummy brown" or "drab," margin paler, "avellaneous" to "drab," disk slightly rugose in large specimens, surface subvelvety, dry but rather transparent, faintly striate, edge even or split at times; lamellae close to subdistant, broad, ventricose, broadly uncinate to adnexed, white, margin dull brown and minutely serrulate; stipe 1–5 cm. × 1–3 mm., equal, long rooting, at first covered by a brown pruinose-fibrous covering, scurfy at maturity, glabrous or with patches of appressed fibrils in age, tough and elastic; spores 6–8 × 4–5 μ, bluntly ovate to broadly ellipsoid; basidia four-spored; cystidia on edge of gills only, 35–45 × 8–12 μ, filled with a brown content, clavate to somewhat fusoid, apex obtuse; pileus with a corticated epidermis often several cells thick; odor and taste not distinctive.

In consistency, stature and structure of the pileus this species is very closely related to *M. atribrunnea* Murr., but the ellipsoid spores, lack of conspicuous cystidia on the sides of the gills and the brown gill-edge easily distinguish it. It can be readily separated from most of the species of the old section *Calodontes* by the very small spores as well as by the structure of the cap trama.

Kauffman, in The Araricaceae of Michigan, p. 792, placed this species in *M. denticulata* Peck, but later recognized that it was distinct.

Mycena quiniaultensis Kauffm. sp. nov.

Gregaria; pileus 1.5–2.5 cm. latus, hemisphericus demum campanulatus, umbonatus, viscidus, striatus, glaber, fuscus demum griseus, membranaceus; lamellae angustae, adnatae, brevissime angulatim decurrentes, subdistantes, albidae demum griseae; stipes 4–7 cm. longus 1.5–2.5 mm. crassus, fuscus demum griseus, glaber, viscidus; sporae 5–6 × 3.5 μ, ellipsoideae; cystidia 80–110 × 5–10 μ, obtuse cylindrica; basidia 30 × 4–5 μ; tetraspora.—Specimen typicum in Herb. Mich. conservatum, prope Lake Quiniault, Washington lectum, October 9, 1935, C. H. Kauffman.

The following description is taken from Professor Kauffman's notes:

Pileus 1.5–2.5 cm. broad, at first subhemispheric then campanulate to subexpanded and umbonate, umbo broad, obtuse, surface viscid, striate to umbo, glabrous, at first entirely fuscous, the mar-

gin fading to "buffy brown" finally "tilleul buff," umbo fading somewhat but darker than the margin at all times; flesh thin, concolorous or paler, almost membranous; gills ascending, narrow, adnate by a decurrent tooth, subdistant at maturity, tinted gray, scarcely intervenose, edge entire and concolorous; stipe 4–7 cm. × 1.5–2.5 mm. equal, colored like the pileus, apex paler or whitish, viscid when moist, naked at apex, glabrous and even, hollow, rigid, white myceloid at base; odor and taste slight or none; spores 5–6 × 3.5 μ, ellipsoid, oblong, hyaline, smooth; cystidia large, 80–110 × 5–10 μ, obtuse and cylindric or slightly enlarged toward the base, smooth, arising in the gill trama; basidia 30 × 4–5 μ, four-spored.

The writer collected this species in Nova Scotia (Colchester County, September 3, 1931, no. *864*) on needles under fir near a small stream. The exceptionally large cystidia are unusual in the Glutinipedes. It is no doubt very closely related to *M. pelliculosa*. The gelatinous layers on both cap and stem are much thinner than in the latter species however, and the cystidia separate it readily.

MYCENA ABRAMSII Murr. Mycologia **8**: 220. 1916.

Pileus 1–3 cm. broad, 1–2 (3) cm. high, conic campanulate or expanded and with a conic umbo, apex rather obtuse, often nearly cylindric before expanding, when young "chaetura black" fading through "fuscous" to "drab," pruinose when young and with a stanneous sheen, glabrous, hygrophanous, sulcate-striate, somewhat translucent at first, very fragile; lamellae adnate, subdistant to distant, narrow to moderately broad, pale gray, edge concolor or whitish; stipe 3–8 cm. long, 1–3 mm. thick, faintly white-fibrous near the base at first, soon concolorous with pileus or evenly pale gray with a whitish apex, covered by an easily removable bloom when young, base white strigose, very brittle; spores 10–12 (16) × 4–5.5 μ, narrowly ellipsoid to subcylindric; basidia four-spored; cystidia scattered on sides and edges of the lamellae, 40–60 × 8–15 μ, smooth, fusoid-ventricose to nearly cylindric with obtuse apices; odor and taste none; gregarious to subcespitose on leaves and debris in frondose woods.

The above description is drawn from the Michigan collections. The species has been found in the spring and fall (June and October). Murrill (**10**) reports it only from the type locality in California. The cystidia on the type are numerous on both the sides and edges of the lamellae, fusoid-ventricose in outline,

smooth and measure 60–80 × 12–16 (20) μ, those on the edge are usually rather short and very broad. The spores measure 10.8–13.5 × 5–6 μ and are narrowly ellipsoid. The basidia are four-spored and measure 32–35 × 7–8 μ.

This species is closely related to *M. aetites,* but the microscopic characters clearly separate the two. The spores are always long and narrow (measurements for different collections are as follows: No. *32–41,* 10–11 × 4–5 μ; No. *32–522,* 12–16 × 4–5 μ; No. *32–622,* 10–12 × 5–5.5 μ) and the base may sometimes be drawn out into a tapering point. Whether or not this species is identical with one described earlier from Europe still remains to be determined. It may possibly be *M. consimilis* Cooke. From the writer's experience it is very difficult to distinguish *M. stannea, M. aetites* and *M. Abramsii* macroscopically. Microscopically they are quite readily separated. *M. stannea* has spores 8–10 × 5–6 μ, fusoid-ventricose cystidia on the sides of the lamellae, those on the edge are provided with one or several finger like prolongations. *M. aetites* has spores practically the same size, but the cystidia are on the gill edge only and of the fusoid-ventricose type.

MYCENA AETITES Fries—*sensu* Bresadola, Iconographia 5: *pl. 244.* (FIG. 2*a.*)

Pileus 1.5–3 cm. broad, obtusely conic when young, becoming expanded umbonate, margin often recurved, blackish when young, "dark mouse gray" more or less after fading, evenly colored, sulcate striate on the margin, cuticle apparently splitting radially producing numerous crowded very fine striations which extend nearly to the disk, hygrophanous, moderately fragile, flesh rather thick on the disk, tapering to the margin; lamellae subdistant, adnate or toothed, narrow to moderately broad, often rather ventricose at maturity, dark gray with a paler margin; stipe 3–6 cm. × 3–4 mm. dark gray, glabrous, translucent, often compressed or twisted; rather tough; spores 8–10 × 5–6 (7) μ, ellipsoid; basidia 27–32 × 6–7 μ, four-spored; cystidia on gill-edge only, fusoid-ventricose, 30–35 × 7–11 μ; odor and taste none.

The material studied was collected on needle beds in a spruce plantation late in the fall (E. B. Mains *31–675,* Ann Arbor, Nov. 15, 1931). The lamellae were not as broad as indicated in Bresa-

dola's description but they were quite ventricose at maturity. In addition the spores were slightly wider than the size given by Bresadola. The fungus is apparently rather rare in the United States. For a comparison with other gray fragile species see *M. Abramsii*.

MYCENA ALCALINIFORMIS Murr. Mycologia **8**: 220. 1916.

Pileus 8–15 mm. broad, conic to nearly convex, very fragile, hygrophanous, glabrous, striate to the disk "fuscous" to "hair brown" over the center, whitish gray on the margin, cinereous when faded, margin even; gills subdistant, adnate or toothed, moderately broad, gray with a whitish margin; stipe 2–4 cm. × 1–2 mm., color of cap or paler, usually whitish above, glabrous, moist and pellucid, very fragile, slightly narrowed below and mycelioid, compressed at times; odor faintly fragrant at first, soon fading; taste mild; spores 7–9 × 4–5 μ; basidia four-spored, 26–29 × 7–8 μ; cystidia on the edge only, 26–33 × 7–10 μ, with obtuse protuberances; pileus with a pronounced vesiculose layer near the surface. Growing densely gregarious on needle beds under coniferous trees.

The spores of the type measure 8–10.5 × 6–7 μ, no cystidia were found on the sides of the gills, those on the edge measure 28–35 × 5–6 μ and are provided with two or more obtuse finger-like prolongations. This species has much the same stature as small forms of *M. metata* and like that species, it has a faint but fragrant odor. The colors clearly ally it to *M. ammoniaca* Fries, from which it is easily distinguished by the cystidia on the gill edge. It is paler and more fragile than either *M. alcalina* or *M. leptocephala*, two other species which also occur abundantly on needle beds and coniferous debris. The writer collected Murrill's species in great abundance on the needle beds under the older white pine stands in the Pack Forest at Warrensburg, N. Y., during the early part of September, 1934. The cystidia in all of these collections consistently possessed the obtuse finger-like prolongations at maturity, whereas those of both *M. leptocephala* and *M. ammoniaca* are smooth or rarely forked in age.

MYCENA ATRIBRUNNEA Murr. Mycologia **8**: 220. 1916.

Pileus 3–15 mm. broad, obtusely conic or oval when young, becoming expanded and umbonate, umbo conic, "bister" or "snuff

brown" when fresh, fading to nearly a "buffy brown" or "fawn color," umbo darker at times but pileus often evenly colored in age, glabrous, lubricous, opaque at first, striate when fading, margin even, often splitting radially in age; lamellae narrowly adnate-uncinate to nearly free, close to subdistant, moderately broad, at times very ventricose, thick, white, pruinose under a lens, edge concolorous; stipe 1–7 cm. × 1–2 (3) mm. pure white, translucent, pruinose at the apex, glabrous, slightly rooting; spores 5–7.5 × 5–6 μ, globose to subglobose, smooth; cystidia on sides and edges of the gills, abundant 60–90 × 8–15 μ, ventricose to cylindric, smooth; pileus trama corticated by an area of inflated globose cells; odor and taste not distinctive.

Gregarious to scattered on rotting logs and stumps and on soil in grassy places under oak trees. In the vicinity of Ann Arbor it has nearly always been collected during the month of June. The cystidia of the type measure 80–120 × 8–15 μ, are very abundant on the sides and edges of the gills, smooth, cylindric to somewhat ventricose, and with obtuse apices. The spores measure 5–6.5 μ and have a pronounced apiculus.

MYCENA CLAVUS (Linn.) Rea, British Basidiomycetae 378.

Agaricus (*Mycena*) *amabillissimus* Peck, Ann. Rep. N. Y. State Mus. **39**: 39. 1887; *Mycena amabillissima* (Peck) Sacc. Syll. Fung. **9**: 37. 1891; *Prunulus amabillissimus* (Peck) Murr. N. Am. Flora 9^5: 324. 1916 (FIG. 1, *a*, *b*).

Pileus 3–20 mm. broad, conic, convex, campanulate or expanded-umbonate, margin at times recurved, evenly "light coral red" when young, fading to white in age or with a sordid yellowish disk; scarcely to distinctly pellucidly striate, glabrous, surface lubricous when moist; lamellae white or coral tinted, adnate, slightly ventricose but not broad, subdistant to distant, edge concolorous, intervenose; stipe 3–5 cm. × (0.5) 1–2 mm., pure white or tinged coral red, base yellowish in age, pruinose and unpolished at first, becoming polished in age, watery fragile; spores 7–9 × 3–4 μ; basidia four-spored; cystidia present on sides and edges of lamellae; 40–65 × 8–12 μ, fusoid-ventricose or with a long acuminate apex; growing singly to subcespitose on leaves and moss.

Rea considers *M. rubella* Quél. as a synonym of *M. Clavus* and quotes von Höhnel who describes cystidia on the edge of the gills only. Boudier, whose illustration Rea cites as *M. Clavus,* clearly shows the cystidia on the sides of the gills. In all of my collections

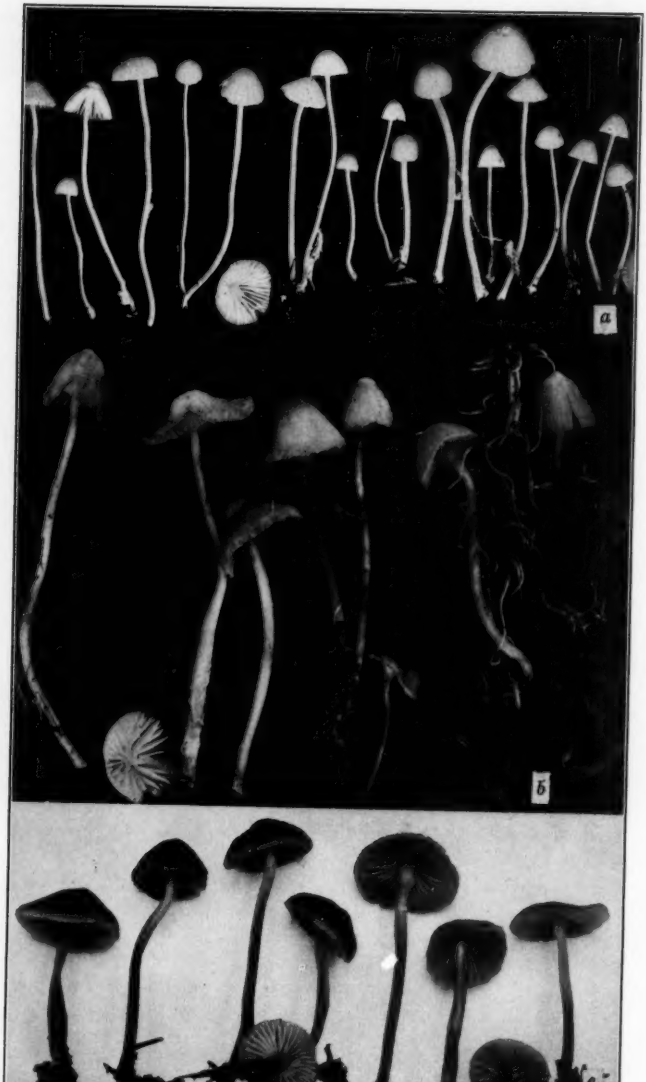

FIG. 1. *a, b, Mycena Clavus; c, Mycena plicosa.*

the cystidia are present on the sides and edges of the lamellae. *Mycena amabillissima* (Peck) Sacc. is the same as *M. Clavus*. The cystidia of the type of *Mycena amabillissima* are present on the sides and edges of the lamellae, fusoid-acuminate, smooth, and measure 36–63 × 6–11 μ. The spores are 5–7 × 3 μ (very few were found) and the basidia are four-spored. The type collection consists of specimens similar to those shown in figure 1, *a*. The writer has collected this species abundantly in sphagnum bogs as well as in open oak woods. The colors are delicate and bright but soon fade. At times the disk fades first becoming pure white or creamy and the margin remains bright pink.

MYCENA ELEGANS (Pers.) Quél. Champ. Jura Vosg. 221. 1872.

Pileus 5–17 mm. broad, up to 10 mm. high, obtusely conic to expanded umbonate, the margin often recurved in age, " fuscous " on the umbo, paler on the margin (usually grayish olive to whitish), when fading becoming yellowish gray to nearly citron yellow except for the darker disk, often whitish over all, at first with a delicate pruinose covering, soon glabrous, hygrophanous; translucent striate, sulcate when faded; lamellae close to subdistant, narrowly adnate, toothed, seceding in age and at times adhering to each other thus forming a collar around the stipe, narrow to moderately broad, whitish, becoming gray (especially at the base), margin concolorous or pale yellow; stipe 3–6 cm. × 1–2 mm., pruinose above, strigose and rooting on leaves at the base, somewhat translucent in age, concolorous with pileus or paler, apex usually paler; spores (7) 8–10 × 4.5–5 μ; basidia four-spored; cystidia scattered on the sides and edges of the lamellae, sometimes rare, 30–40 × 12–20 μ, clavate, apices obtuse and covered by numerous fine echinulations; odor and taste not distinctive.

The fungus described above has been found regularly every fall in an oak woods near Ann Arbor. The colors were never as bright as those described for *M. aurantio-marginata*, but robust individuals with bright yellow pileus margins have been collected. The gill edges are usually a bright clear yellow but occasionally the color is absent entirely. The fibrils at the base of the stem were white to grayish white. Konrad and Maublanc (7) consider *M. elegans* to be a gray form of *M. aurantio-marginata*.

MYCENA FAGETORUM Fries, Epicr. Myc. 106. 1838.

Pileus 1–2.5 (3.5) cm. broad, obtusely campanulate when young, soon broadly convex or plane, margin often reflexed in age, "drab" or darker on the apex, margin whitish, becoming "wood brown" to "buffy brown" or "avellaneous" on the disk, in age "mouse gray" to "light grayish olive" and finally fading to pale cinereous or evenly whitish gray, glabrous, lubricous, scarcely hygrophanous, translucent striate when fresh, at times sulcate in age; flesh thick on the disk, thin on the margin, watery gray; lamellae close to subdistant, interspaces usually venose, adnate with a tooth to adnexed, often adhering together when separated from the stipe and forming a collar around it, narrow to broad and often very ventricose, pale to ashy gray, occasionally with a faint incarnate tinge, edge concolorous, in age often stained with sordid brownish spots; stipe 4–7 cm. × 2–4 mm., "Quaker drab" when fresh and covered with a removable pruinosity, translucent at maturity, paler to nearly white in age, often twisted, rather tough to fragile, white strigose at the base, usually with a long horizontal strigose root under the leaves; odor and taste not distinctive; spores 7–9 × 3–4 μ, 8–10 × 3–4 μ, very narrowly pyriform; basidia four-spored, 25–30 × 6–7 μ; cystidia on gill-edge only, clavate, with wavy outlines or short obtuse projections covering the apex, 30–35 × 7–10 μ; pileus trama homogeneous. Caespitose to scattered among oak leaves late in the fall.

The margin of the pileus is frequently incurved. This led me to search for the species in *Collybia* at first. Ricken's description and illustration fit the Michigan fungus well except that the latter has never been found in a woods where beech trees were present. The species was very abundant in one locality during October 1931 and again in November 1934, but has been only occasionally collected otherwise. The homogeneous pileus and incurved margin indicate a strong relationship with *Collybia* where it perhaps should be placed.

MYCENA IODIOLENS Lundell, Sv. Vet.-Akad. Skr. **22**: 7. 1932.

Mycena graveolens Kauffm. & Smith Papers Mich. Acad. **17**: 181. 1933.—From the descriptions it is clearly evident that the fungus Lundell described is the same as that described as *M. graveolens*. It is a curious coincidence that the species should be found in the Caucasus Mts. (see notes under *M. psammicola*), in Sweden, and in the United States in the period between 1929 and 1932.

MYCENA LACTEA var. PITHYA (Pers.) Fries—*sensu* Rea, British Basidiomycetae, p. 381. 1922.

Pileus 3–10 mm. broad, convex to obtusely conic, becoming nearly expanded, margin often recurved, usually grayish on the disk and pure white toward the margin, at times pure white or creamy on the disk, sulcate striate, surface dull; lamellae white, very distant, very narrow, bluntly adnate or with a very slight tooth, edge concolor; stipe 10–20 × 0.5–0.7 mm. pure white, evenly pruinose when young, glabrous in age, base inserted on bark but with a few radiating fibers; spores 7–8 × 5–6 μ, "drop" shaped; basidia two-spored; cystidia on edge only, smooth, 30–35 × 7–10 μ.

On the bark of a beech log, Warrensburg, N. Y., Sept. 12, 1934. This is a fragile plant with narrow distant gills, otherwise it is similar to the typical form of the species.

MYCENA ODORIFERA (Peck) Sacc. Syll. Fung. **5**: 295. 1887.

Pileus 4–10 mm. broad, convex, papillate or center slightly depressed, viscid, glabrous, hardly striate, bluish gray on apex, white on margin, becoming sordid gray or brownish in age, very tough and cartilaginous; lamellae close to subdistant, white to pale gray, adnate but becoming decurrent in age, narrow to moderately broad, tapering to the margin; stipe 1–2 cm. × 1 mm. very cartilaginous, dark gray to bluish gray and covered by a dense rather coarse white pruina, paler and glabrous in age, viscid; spores 7–8 × 3–4 μ, broadly ellipsoid; basidia four-spored, 30–35 × 5–6 μ; cystidia on gill-edge only, filamentose, 38–46 × 6–7 μ, smooth; pileus covered by a thick gelatinous pellicle, stipe surrounded by a layer of gelatinizing hyphae; odor striking and pleasant; taste none; gregarious or scattered on moss and debris. Apparently a very rare species.

The spores of the type measure 7–8 × 3 μ. The basidia are both two- and four-spored, and the cystidia on the gill-edge are approximately filamentose in outline, 38–47 × 5–7 μ. A few were found with forked apices. The gelatinous layer on the pileus is thick, forming about half the cap trama. In the writer's collections the thickness of the pellicle varies considerably. This species was collected at Pinckney and Cross Village in Mich. (*33–592* and *33–695*), during July and August 1933. The odor somewhat resembles that of *Armillaria caligata* Viv.

MYCENA PELLICULOSA Fries, Epicr. Myc. 116. 1838.

Pileus 5–10 mm. broad, convex with an abrupt and rather broad depression on the disk, viscid, glabrous, fuliginous, fading to pale gray and at times assuming brownish tints, striae conspicuous, darker than the remainder; lamellae distant, white, arcuate-decurrent, narrow to moderately broad, edge even and concolor, stipe 1–2 cm. × 1 mm. pallid or concolorous with the pileus, pruinose over all when young, viscid; odor and taste none; spores 7–9 × 4–5 μ (*33–712*) or 8–10 × 4–5 μ (*33–706*); basidia four-spored; cystidia on gill-edge clavate, roughened with short irregular blunt projections, soon gelatinizing; pileus trama divided into three zones, a surface zone composed of a gelatinizing pellicle ½ to ⅔ the thickness of the entire cap trama, below this a narrow central layer of non-gelatinous interwoven hyphae, the subhymenial zone of gelatinous hyphae and extending to the gelatinous gill-edge (thus the central tissue of the pileus and gill-trama is enveloped on both sides by gelatinizing layers); the stipe has a thick sheath of gelatinizing hyphae. Gregarious on conifer duff and humus under conifers. The entire fruit-body is very tough and cartilaginous.

The above description was drawn from collections *33–706* and *33–712*, Cross Village, Mich., Aug. 19, 1933. From the writer's experience this fungus is rare. The species as reported by European investigators seems to be larger and often obtusely umbonate. The gelatinous subhymenium is not mentioned as a character of *M. pelliculosa*, but this could easily have been overlooked as has apparently happened in many studies of *Hygrophorus laetus* Fries. The thickness of the gelatinous layer on the pileus varies greatly depending on the weather conditions and after heavy rains the cap may be nearly dry.

MYCENA PELTATA Fries, Epicr. Myc. 110, 1838.

Pileus 8–20 mm. broad, convex to obtusely campanulate when young, at maturity occasionally with an obtuse umbo, usually convex to plane, at times with a shallow depression on the disk, at first densely pruinose to frosted, soon glabrous, surface lubricous to subviscid from a very thin adnate gelatinizing pellicle, nearly opaque to faintly striatulate when moist, striae more conspicuous as the colors become lighter, disk usually "fuscous" at first, margin close to "hair brown," in age evenly "drab-gray" or pale cinereous and rather evenly colored; lamellae moderately broad, white to pale grayish at base, adnate with a decurrent tooth, close,

edge concolorous or white; stipe 3–5 cm. × 1–1.5 mm. (when in deep moss 8–15 cm.), concolorous with pileus or paler, glabrous above, densely white fibrous below, rather tough and cartilaginous, not viscid, with or without a small abrupt bulb at the base; odor and taste not distinctive; spores 8–10 × 3.5–4 μ; basidia four-spored; cystidia on the gill-edge only, basidia-like, 28–30 × 6–9 μ, with wavy outlines or with several finger-like prolongations near the apex; pileus with a region of enlarged cells beneath the cuticle which are filled with a dull brown substance.

On grassy hummocks and on sphagnum, Rees's Bog, Burt Lake, Cheboygan Co., Mich., Oct. 15, 1934 (*1157*). In consistency this species resembles *M. latifolia* Peck very closely and small forms, in addition, resemble it in color and stature as well. These are easily distinguished by the cystidia however. Those of *M. latifolia* are present on sides and edges of the gills. Those on the sides are fusoid-ventricose in outline with the inflated portion smooth or slightly roughened. Those on the gill-edge are either clavate and roughened or fusoid-ventricose with the enlarged portion roughened by blunt short rod-like projections. Killerman (**6**) describes our plant well. Ricken (**12**) p. 442, describes *M. peltata* as having cystidia 40 × 12–15 μ and so conspicuous that "Durch die Cystiden erscheinen die Lamellen unter der Lupe weissmehlig." Ricken's fungus may possibly be *M. latifolia* which in addition has spores 6–8 × 3–4 μ.

MYCENA PLICOSA Fries, Syst. Myc. **1**: 145. 1821. (FIG. 1, *c*.)

Pileus 1–2 cm. broad, convex to broadly subconic at first, becoming hemispheric or expanded and broadly umbonate, surface dry, densely pruinose at first, glabrous, blackish when young to dark grayish brown, becoming "drab" to "avellaneous" or dull lead color, somewhat paler to nearly whitish in age, usually dull grayish brown and unicolorous, sulcate striate to "scalloped" on the margin, hardly hygrophanous; lamellae close, narrow to broad, adnate with a tooth, drab to grayish or creamy, faint flesh tint discernable in age, often staining reddish brown where bruised, margin concolorous; stipe 2–5 cm. × 1–2 mm. densely pruinose, soon polished, often longitudinally twisted striate, rigid and fragile, concolorous with the pileus or nearly white at the apex; narrowed below at the point of attachment or equal, base somewhat white strigose, spores 7–9 × 3.5–4 μ, basidia four-spored, cystidia 26–30 × 8–11 μ, capitate to clavate, apex covered by short rod-like

projections; odor and taste none. Gregarious on needle beds under spruce and pine.

In color the Michigan collections differ from Ricken's description but correspond closely to the description of Fries. The fungus varies greatly in stature and in the markings on the pileus. Forms with a "scalloped" margin have been collected as well as forms with plicate pilei. The lamellae in the writer's collections were neither distant nor exceptionally thick for the species in this genus and differ in these respects from the Friesian conception.

MYCENA PSAMMICOLA (Berk. & Br.) Sacc. Syll. Fung. **5**: 275. 1887.

Pileus 5–10 mm. broad, broadly campanulate to expanded umbonate, "tawny" or with a "russet" cast, "ochraceous-tawny" near the margin and disk "mars brown" when fresh, umbo "fuscous" at times, pale "ochraceous-tawny" to "cinnamon-buff" when faded, edge even, concolorous; stipe 2–5 cm. × 1 mm., "ochraceous-tawny," apex pallid, equal, glabrous, white fibrous at base, apex pruinose; spores 7–8 × 3.5–4 μ; basidia 26–28 × 6–7 μ, four-spored; cystidia on gill edge only, 20–35 × 10–12 μ, covered by coarse somewhat pointed projections; odor fragrant, resembling iodoform and developing after the fruit-bodies have been collected, taste none. Gregarious on needle beds under pine and on humus in swampy places.

This species can easily be mistaken for a small *Galerula*. The spore print however is white. Singer (**13**) places collections with an odor resembling iodoform in *M. psammicola*, but describes the colors as "grau weiss, spores 9–10 × 6–6.5 μ." This is very likely *M. iodiolens* Lundell. The decided brown to ochraceous colors of *M. psammicola* easily separate it from the gray species related to *M. filipes*.

MYCENA PULLATA (Berk. & Cooke) Sacc. Syll. Fung. **5**: 277. 1887.

Pileus 5–20 mm. broad, obtusely conic, becoming broadly campanulate to expanded umbonate, colors when young and fresh "army brown," "bone brown," "vinaceous-brown" or "dark purple-drab," fading to "vinaceous-drab" or "natal brown," colors often dull and sordid in age, margin often grayish, at first covered by a faint bloom, glabrous, dry, somewhat sulcate striate near the

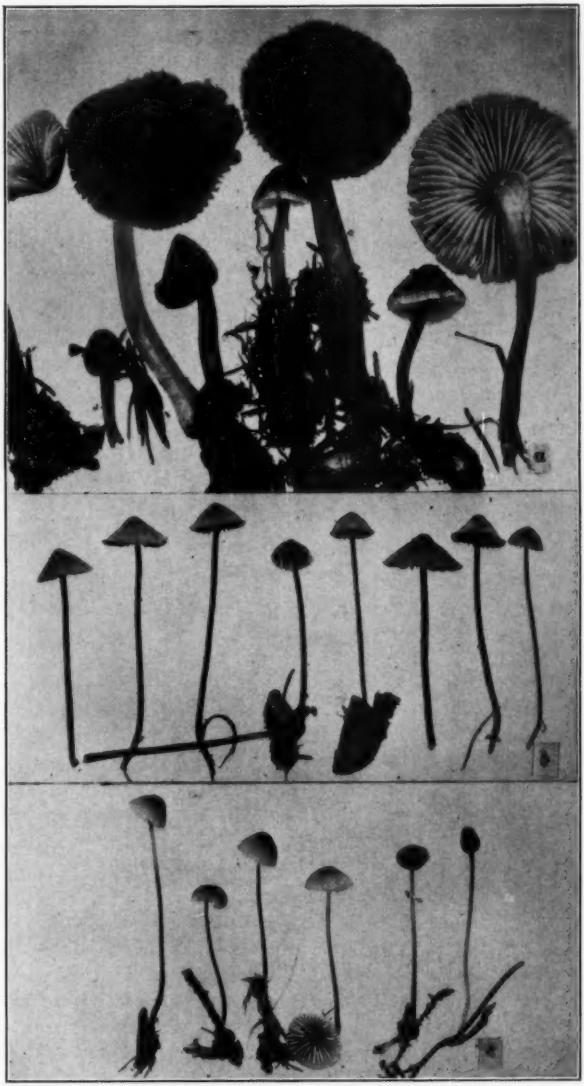

FIG. 2. *a, Mycena aetites; b, Mycena psammicola; c, Mycena urania.*

margin; flesh rather tough-cartilaginous; lamellae narrow to moderately broad, close to subdistant, narrowly adnate, whitish cinereous or vinaceous drab, usually concolorous with the pileus in age; stipe 4–15 × 1–2 mm. very rigid-cartilaginous, "purple-drab" to "vinaceous-drab" or "vinaceous-fawn" often grayish below, faintly fibrous pruinose above, usually longitudinally fibrous striate but glabrous and polished at times, white mycelioid at base; spores 8–10 × 6.5–7.5 μ, 8–10 × 5–6 μ, 8–11 × 5.5–6.5 μ or 9–11 × 5–6 μ in different collections, ellipsoid; cystidia on gill-edge smooth or with finger-like prolongations, fusoid-ventricose to clavate before branching, 25–35 × 7–9 μ; odor and taste not distinctive.

Whether or not the fungus described above is properly placed in *M. pullata* is a matter of opinion. The dark colors with a purplish brown cast and the stature as shown in Cooke's illustration (**4**) indicate a very close relationship to the Michigan collections. Atkinson (**1**) considered this fungus to be the American form of *M. polygramma* chiefly because of the longitudinal fibrous striations which may be present on the stipe. Specimens of the latter species from Europe in the Atkinson collections and from England in the University of Michigan Herbarium do not satisfactorily confirm this disposition of the fungus. The colors of *M. pullata* as described here are strikingly different from those usually attributed to *M. polygramma* and have been observed to be constant in their range of variation during the past five seasons. The species grows singly among the leaves and on humus in oak woods around Ann Arbor, and has almost invariably been found in company with *Mycena vitilis*.

MYCENA URANIA Fries, Syst. Myc. **1**: 144. 1821. (FIG. 2, *c*.)

Pileus 4–10 mm. broad, conic to hemispheric, occasionally broadly umbonate, usually convex in age, "dark plumbeous" or "deep Varley's gray" when fresh, dark bluish gray colors quite pronounced, fading through "lilac-gray" or violet grays and finally pale drab, margin slightly paler when fresh, with a hoary sheen at first, glabrous and dull in age, rather dry, margin more or less sulcate striate and somewhat crenate at times; lamellae narrow, subdistant to distant, broadly adnate to uncinate-adnate, white or whitish when young, becoming bluish or pallid gray, edge concolorous; stipe 1–3 cm. × 0.5–1 mm. "pale violet-gray" to "deep Varley's gray," becoming paler, dry, with a hoary unpolished appearance at first, the apex slightly pruinose, rigid, tubular; spores

7–9 × 4–5 μ, ellipsoid; basidia four-spored, 20–25 × 6–8 μ; cystidia present or absent on the sides, numerous on the edge, 26–30 × 8–10 μ, clavate, the apex covered by short rod-like processes; odor and taste none. Gregarious on wet swampy ground among mosses and decaying leaves during the late summer and fall. Apparently a very rare species in Michigan.

Fries described the stem as flaccid and the gills as white. In my collections the stems were usually rigid enough to hold the small caps upright although fruit-bodies from mossy places were often rather decumbent. In addition the gills were always dark. Differences such as these however, have been observed in individuals of single collections of many other species and are not considered sufficient to separate the American collections. The microscopic details of the species are very poorly known, and are omitted in most of the descriptions. *M. atrocyanea,* which it apparently resembles in color, is ordinarily classed in the fragile group. If Ricken's interpretation of the latter is correct *M. urania* is easily separated from it by the clavate roughened cystidia.

MYCENA VITILIS Fries, Epicr. Myc. 113. 1838.

Pileus 5–10 mm. broad, conic, campanulate or nearly expanded and somewhat umbonate, "drab" when faded, brownish colors more evident when fresh, striate, subviscid to lubricous when moist but pellicle very thin and adnate, glistening when dry, at times unpolished, glabrous, margin even; flesh rather leathery in consistency; lamellae close, narrow, equal, white or grayish, attached by a tooth to narrowly adnate, edge concolor and often slightly eroded; stipe 6–12 cm. × 1–1.5 mm., bluish black at first, soon gray, nearly concolorous with the pileus in age, apex somewhat fibrous striate at first, tough, flaccid in age, strigose at the base and rooting in the debris, often attached to small sticks; spores 9–11 × 5–6 μ; basidia four-spored; cystidia occasionally on the sides, frequent on the edges of the lamellae, 30–40 × 8–14 μ, fusoid-ventricose or with several contorted prolongations.

Not much concerning the occurrence of this species in the United States seems to be known. It has been found rather abundantly late in the fall (October and November) in the oak woods around Ann Arbor. Lange's (8) description and comments describe the Michigan collections accurately. It is nearly always attached to small sticks buried in the leaves and debris, and the stem is usually

very crooked. When the weather conditions are exceptionally favorable robust forms are found occasionally which are strict and rigid in their appearance. The consistency is decidedly more cartilaginous than that of *M. filipes*, and the cystidia separate the two readily.

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NOTES ON SOME SPECIES OF THE UREDINALES[1]

GEORGE B. CUMMINS

(WITH 5 FIGURES)

The miscellaneous notes which follow in this paper have been assembled from time to time as interesting collections have been received or old collections restudied. They include new records for the United States, new species, new combinations and revised descriptions. All specimens, including types, are deposited in the Arthur Herbarium of this institution.

UREDO DIOSCOREAE-ALATAE Racib.

While studying a collection of rusts on some species of *Dioscorea* from the Philippine Islands sections were made of specimens of this species as represented in the Arthur Herbarium. One specimen was collected by P. W. Graff at Manila, Luzon, P. I., Dec. 2, 1912, and issued by Sydow in his *Fungi Exotici* as no. *230*. The other was collected at Bangai village, Samoa, June and July 1926, by H. E. Parks as no. *8558*. Both are on *Dioscorea alata*.

The uredia in Graff's collection are deep in the tissue of the leaf, apparently located about midway between the upper and lower epidermis and thus agree with the description given by Raciborski (**13**) for *Uredo Dioscoreae-alatae*. In Park's collection the uredia are just beneath the lower epidermis. The urediospores correspond closely in both collections and despite the difference in the position of the sori the two collections certainly belong to the same species.

Highly gelatinized telia (FIG. 1, *2A*) are present in abundance in both collections. These telia are subepidermal in origin and show young spores almost as soon as the development has progressed to a point where the primordial sorus can be differentiated

[1] Contribution from the Botany Department, Purdue University Agricultural Experiment Station, Lafayette, Indiana.

from the host tissue. The gelatinous matrix in which the spores are imbedded appears to be present from the beginning, and as soon as the epidermis ruptures, it protrudes above the surface of the host as a hyaline umbo. From this it appears probable that the epidermis is ruptured by the swelling of the matrix, because the delicate teliospores not only appear to be inadequate for such a task but are seldom pressed against the epidermal cells. Once the epidermis is ruptured the telia spread laterally to a considerable extent and often unite with other sori to form a nearly continuous telial layer 200 to 300 μ or more in extent. The upturned epidermis usually remains visible between such groups of telia.

The teliospores are cylindrical, straight or more or less sinuous and complete their development within the gelatinous matrix, only the basidiospores being liberated above its surface. Details at the base of the sorus are difficult to see but apparently more than one teliospore is produced from a single basal cell by lateral budding (FIG. 2*A*). In this way several generations of teliospores in different stages of development are present in a single sorus. The germinated spores collapse, making space for succeeding generations of spores.

Germination takes place by the formation of an internal basidium, *i.e.*, the teliospores become 4-celled by the development of septae, and each cell then produces a sterigma which proceeds upward through the gelatinous matrix and liberates a single basidiospore above the surface of the matrix. The teliospores are somewhat variable in size, measure 8–10 by 46–60 μ and have a smooth, hyaline wall, less than 1 μ in thickness.

The characters given here for the telia of this species correspond so closely with those of the genus *Goplana*, as described by Raciborski (**13**), that I have no hesitation in transferring the species to that genus. Only three species, all from Java, have previously been included in the genus. Uredia have not been described for any of the three.

This fungus was first described by Berkeley and Broome (**4**) as *Aecidium Dioscoreae* and later transferred to *Uredo* by Petch (**11**), who pointed out that it was apparently identical with *U. Dioscoreae-alatae* Racib. (*l. c.*). Petch's transfer was not valid since Henning (**8**) had previously used the name for a *Uredo* now con-

sidered to be a synonym of *Sphenospora pallida* (Wint.) Diet. Since *Aecidium Dioscoreae* Berk. & Br. is the first name applied to this fungus and since the name was given to the diploid or per-

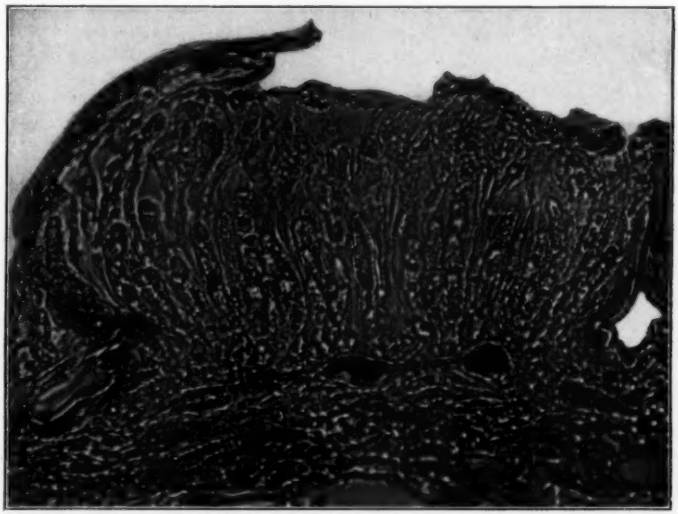

FIG. 1. This photograph was taken of a freehand section of a telium of *Goplana Dioscoreae* (from Sydow's *Fungi exotici 230*, issued as *Uredo Dioscoreae-alatae* Racib.). The general characters of the telium are shown with the teliospores developing upward in the gelatinous matrix. No germination has occurred. (See also fig. 2*A*.) × about 500.

fect state the specific name becomes available when placed in a genus other than the form-genus *Uredo*, and is not affected by Hennings' name which was given later. This usage is in accord with Arthur's (3) interpretation of the rule. Accordingly the name and synonymy of this species is as follows: **Goplana Dioscoreae** (Berk. & Br.) comb. nov. (*Aecidium Dioscoreae* Berk. & Br., Jour. Linn. Soc. Bot. **14**: 95. 1875; *Uredo Dioscoreae-alatae* Racib. Paras. Algen und Pilze Javas I, 29. 1900; *Uredo Dioscoreae* Petch, Ann. Roy. Bot. Gard. Peradeniya V. **4**: 252. 1912, not *Uredo Dioscoreae* Henn. Hedwigia **35**: 255. 1896.

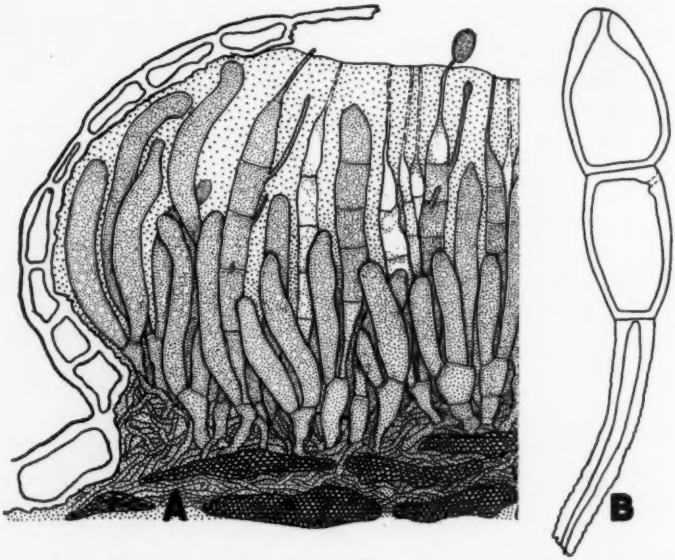

FIG. 2. *A*. This camera lucida drawing represents a telium of *Goplana Dioscoreae*. The spores are imbedded in a gelatinous matrix, germinate by an internal 4-celled basidium, produce sterigmata which grow through the matrix and produce one basidiospore each above the surface of the matrix. Germinated teliospores collapse and are followed by succeeding generations of new spores as shown. More than one spore apparently comes from a single basal cell in the manner shown. The dark areas at the base of the sorus represent collapsed host-tissue. *B*, a teliospore of *Puccinia Parksiana*. The teliospores in this rust are a bright golden-brown and have thick-walled pedicels concolorous with the walls of the spores. × about 650.

Puccinia Parksiana sp. nov.

Teliis hypophyllis, rotundatis, compactiusculis, rufobrunneis, circinnatis in maculis 4–10 mm. diam.; teliosporis (TEXT FIG. 2*B*) oblongis, 22–26 × 55–80 μ, apice et basi rotundatis, medio constrictis; membrana 2–3 μ cr., apice incrassatis 4–6 μ, aureo-flavidis, levis; pedicello concolori, persistenti, usque 60 μ longo 13 μ crasso.

On *Smilax vitiensis* Seeman, near Suva, Fiji, May 1926. *H. E. Parks 8500*.

No other spore-form is present in this material and there is no doubt that the species is microcyclic. The telia are arranged in from three to five concentric rings. The teliospores resemble those

of *Puccinia Smilacis-chinae* P. Henn. and *P. Merrillii* P. Henn. in shape and color but differ in having non-inflated pedicels.

The species is named in honor of the collector, Mr. H. E. Parks of Trinidad, California, who is at present contributing important information regarding the rust-flora of northern California in addition to his earlier collections of such exotic species as the one described above.

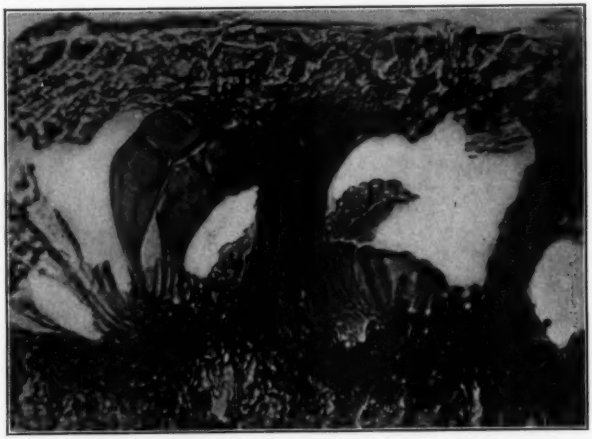

FIG. 3. *Puccinia liberta* Kern. The photograph shows the subepidermal, locular, paraphysate telia present in the type specimen (on *Eleocharis* sp., Grenada, dept. Grenada, Nicaragua, Feb. 11, 1903. *C. F. Baker 2385*).

PUCCINIA LIBERTA Kern

Telia of this species have seldom been collected but they were found to be plentiful in a specimen on *Eleocharis palustris* (L.) R. & S. collected by H. E. Parks at Dry Lagoon, Humboldt Co., Calif., Sept. 1934. In studying the telia in section it was found that the teliospores are formed in subepidermal locules surrounded by paraphyses. No such structures were mentioned by Kern (**9**) when he described the species but after sectioning telia present in the type collection (on *Eleocharis* sp., Grenada, dept. Grenada, Nacaragua, Feb. 11, 1903. *C. F. Baker 2385*) it was found that paraphyses are also present in the type (FIG. 3).

UROMYCES SCIRPI (Cast.) Burr.

Uromyces Scirpi as represented in the Arthur Herbarium and as published by Arthur (**1, 2**) is composed of two clearly defined species, separable by morphological characteristics of both the urediospores and the telia. These differences came to my attention while studying a specimen on *Scirpus californicus* (Mey.) Britt. collected by H. E. Parks (no. *5156*) at Dry Lagoon, Humboldt Co., Calif., Sept. 14, 1934. This specimen differed from published descriptions of *U. Scirpi* in having larger urediospores with more germ pores, indehiscent, substomatal, loculate telia surrounded by brown paraphyses and longer teliospores with pale, thin walls and short pedicels. The differences in the appearance of the telia of the two species is shown in the photographs taken of free-hand

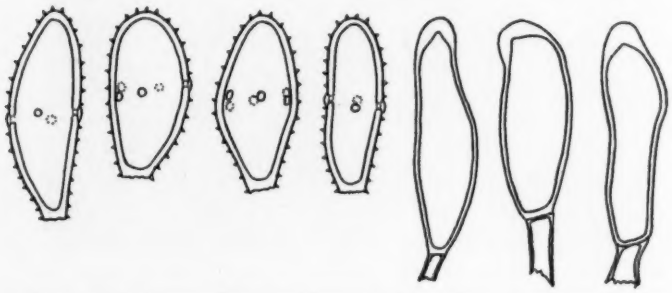

FIG. 4. Urediospores and teliospores of *Uromyces americanus* Speg. Drawn with the aid of a camera lucida from type material (near Mendoza, Argentina, January 1908. *C. Spegazzini*). × about 650.

sections and reproduced in Figure 5: *A* is from Spegazzini's type of *Uromyces americanus, B* is from a specimen of *U. americanus* on *S. validus* from Wisconsin, and *C* is from a specimen of *U. Scirpi* on *S. campestris* from North Dakota.

A study of all of the material assigned to this species in the Arthur Herbarium proved that this form was abundantly represented. No published description was found which could apply to this rust. However, a specimen collected on *Scirpus americanus* near Mendoza, Argentina in January 1908 by Spegazzini proved to be identical when studied in section. This specimen was published by Spegazzini (**14**) as *Uromyces? americanus* Speg. (n. sp.).

Spegazzini's description makes no mention of the loculate character of the telia and describes the urediospores as globoid. Since the specimen which I have studied is a part of Spegazzini's type (sent to Dr. J. C. Arthur by Spegazzini in September 1920) it has been possible to detect the inadequacy of his description and to establish the fact that *U. americanus* Speg. is a valid species represented in the flora of both North and South America and easily distinguished from *U. Scirpi* (Cast.) Burr. Petrak and Sydow (**12**) have also pointed out the fact that *Uromyces americanus* is to be considered as distinct from *U. Scirpi* and found in addition that *Macrophoma americana* Speg. is a rust and was described from telial material of *U. americanus*.

A redescription of the species together with the hosts and distribution follows:

Uredia on the stems, subepidermal, covered by the epidermis and opening by a longitudinal slit, oblong, 0.5–1 mm. long, cinnamon-brown; urediospores (FIG. 4 *from type*) variable in size and shape, oblong, ellipsoid or spindle-shaped, 15–25 × 31–50 μ; wall 1.5–2 μ thick, pale cinnamon-brown, finely echinulate, the pores 4–6, equatorial, distinct. Telia (FIG. 5, *A. type; B. Wis.*) on the stems, in blackish spots of varying size, subepidermal, indehiscent, loculate, round, 50–70 μ in diameter, surrounded by subepidermal paraphyses; teliospores (FIG. 4 *from type*) variable, oblong or cylindric, 14–21 × 39–65 μ; wall 1 μ thick at sides, 3–5 μ above, yellowish or nearly colorless, smooth, the pore apical; pedicel short, hyaline or tinted.

On *Scirpus americanus* Pers., Ala., Del., Tex.; Bermuda; Argentina.—*S. californicus* (Mey.) Britt., Calif.—*S. validus* Vahl. Ind., Neb., Wis.; N. S., Ont.

No cultures have been reported for this species.

The segregation of *U. americanus* from *U. Scirpi* necessitates some revision of the description of *U. Scirpi* given in the N. Am. Flora and Arthur's "Manual." The telia (FIG. 5, *C*) were found to have a few paraphyses but are always erumpent and dehiscent. The teliospores measure 14–22 by 26–50 μ. *Scirpus americanus* and *S. validus* should be omitted from the list of hosts. The records for *S. americanus* from Indiana and Wisconsin should be credited to *S. fluviatilis*. *Uromyces? americanus* Speg. should be removed from the synonymy.

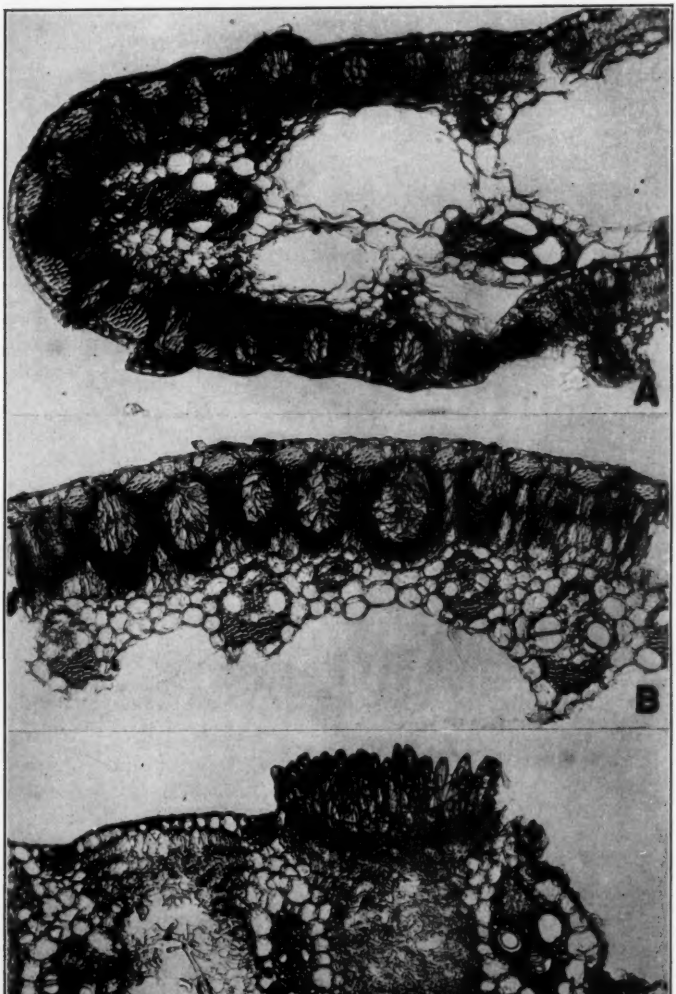

FIG. 5

UREDO ERICAE Naumann

In 1934 Diehl (**6**) reported a rust on *Erica* sp. (*E. hyemalis* Nichols), collected by G. L. Stout at Colma, Calif., July 12, 1934, as *Uredo Ericae* Naumann. Diehl's identification was tentative since he had no material for comparison, and at the time that it was sent to this laboratory for verification no material was available in the Arthur Herbarium. Since then a fragment of *U. Ericae* has been received from Dr. G. Samuelsson of the Naturhistoriska Riksmuseet, Stockholm which was collected at Leipzig, Germany, in 1913 on *Erica gracilis* by Naumann.

Free-hand sections proved that *U. Ericae* has a well developed cellular peridium which was not included in the description given by Naumann, although he mentions, in his general discussion, that he observed a peridium-like structure in sections of the sori. In this respect *U. Ericae* and the collection from California agree. The urediospores also correspond, being ellipsoid and having eight scattered pores in an echinulate, colorless wall 1.5 μ thick. I find no characters which would warrant a separation of the two collections.

Diehl also pointed out that the rust from California was apparently identical with *Thecopsora Fischeri* Cruchet, after comparing it with material from Spain. Dr. Cruchet kindly sent me two collections of his fungus and through the kindness of Dr. Sydow I have also been able to examine Cruchet's type collection. The fungus has a peridium as described and illustrated by Cruchet (**5**). For a more accurate description and illustration see also Gonzáles Fragoso (**7**).

A few hyaline thin-walled paraphyses are present at the base of the sorus inside of the peridium in *U. Ericae*. Such paraphyses were not seen in *T. Fischeri* but were found in the California specimen. These structures might easily be overlooked and do not warrant separate specific names for these two fungi since the urediospores and the peridium are the same in both.

Because of the morphological characteristics of the uredia *Uredo Ericae* is placed in the genus *Pucciniastrum* as **P. Ericae** (Naumann) comb. nov. with the synonymy as follows: *Uredo Ericae* (Naumann, Jahresb. Vereinig. angew. Bot. **9**: 207. 1912; *The-*

copsora Fischeri Cruchet, Bull. Soc. Vaud. Sci. Nat. **51**: 77. 1916).

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EXPLANATION OF FIG. 5

FIG. 5. The photographs were all taken of free-hand sections at a magnification of about 150 diameters. *A*, the loculate telia present in the type material of *Uromyces americanus* Speg. (on *Scirpus americanus* near Mendoza, Argentina, January 1908. *C. Spegazzini*); *B*, telia of *U. americanus* (on *Scirpus validus*, Madison, Wis., June 6, 1907. *E. W. Olive*); *C*, telia of *Uromyces Scirpi* (Cast.) Burr. (on *Scirpus campestris*, Kulm, N. D., Sept. 1909. *J. F. Brenckle 326*, Brenckle *Fungi Dakot. 120*).

NOTES ON SOME FUNGI FROM COLOMBIA

F. D. Kern and R. A. Toro

In the spring of 1934 the writers spent some time in South America, chiefly in Venezuela, making mycological explorations and collecting specimens. While spending some time in the State of Tachira, Venezuela, the nearness to the Colombian border tempted us to cross over and do a bit of collecting there. The specimens here reported were collected in the vicinity of Cucuta, Department Norte de Santander, Colombia, on May 11, 1934.

Our knowledge of the fungous flora of Colombia is well presented in a paper entitled " Mycological Explorations of Colombia " by Carlos E. Chardon and Rafael A. Toro, Journal of the Department of Agriculture of Puerto Rico **14**: 195–369, 1930. Further information regarding the Uredinales there is to be found in an " Annotated Index of the Rusts of Colombia " by F. D. Kern, H. W. Thurston, Jr., and H. H. Whetzel, Mycologia **25**: 448–503, 1933.

We are indebted to the administrative officers of the University of Puerto Rico, especially Chancellor C. E. Chardon, for making possible our trip to South America and to various officials and friends there for assistance and courtesies which were accorded to us. We acknowledge also with thanks the aid of several phanerogamic botanists in identification of hosts.

Phyllachora machaeriicola (P. Henn.) Th. & Syd. Ann. Myc. **13**: 504. 1915.

Physalospora machaeriicola P. Henn. Hedwigia **43**: 243. 1904.

A very common species on this host in Venezuela. Reported here for the first time from Colombia.

On *Machaerium Humboldtianum* Vogel, *Kern* & *Toro* no. *1*.

HYPOSPILINA OSPINAE (Chardon) Chardon & Toro, Monog. University of Puerto Rico, series B, **2**: 192. 1934.

Gnomonia Ospinae Chardon, Bol. Real Soc. Esp. Hist. Nat. **28**: 120. 1928.

On *Tecoma pentaphylla* Juss., *Kern* & *Toro* no. *4*.

Septoria cucutana sp. nov.

Maculae laxe vel densiuscule per folium dispersae, in utraque pagina visibiles, ambitu orbiculares v. irregulares, primitus griseobrunneae, dein pallescentes albidae, linea marginali obscure rufobrunnea plerumque valde elevata acutissime definitae, .5–2 mm. diam.; pycnidia epiphylla, sat regulariter densiusculeque per macula dispersa, depresso-globosa, 90–110 μ diam., ostiolo tantum plano papilliformi poro rotundo aperto punctiformiter errumpentia; pariete membranaceo, contextu subhyalino, dilute griseo-brunneolo fibroso; conidia filiformia, utrinque plerumque leniter attenuata, obtusa, vermicularicurvata, hyalina, 34–40 × .8–1 μ.

In foliis *Tecoma pentaphyllae* Juss., *Kern* & *Toro* no. *5*.

CEROTELIUM DESMIUM (Berk. & Br.) Arth. N. Am. Flora **7**: 698. 1925.

Uredo Gossypii Lagerh. Jour. Myc. **7**: 48. 1891.

On *Gossypium peruvianum* Cav., *Kern* & *Toro* no. *3*.

A common species wherever *Gossypium* grows. Previously collected in Colombia both by Mayor and Chardon.

PUCCINIA CENCHRI Diet. & Holw.; Holw. Bot. Gaz. **24**: 28. 1897.

On *Cenchrus echinatus* L., *Kern* & *Toro* no. *6*.

PUCCINIA OBLIQUA Berk. & Curt.; Berk. Jour. Linn. Soc. **10**: 356. 1869.

On *Mesechites trifida* (Jacq.) Muell. Arg., *Kern* & *Toro* no. *9*.

The use of this name for a rust on *Mesechites* which belongs to the family Apocynaceae is somewhat doubtful. Up to this time *Puccinia obliqua* has been used only in connection with hosts belonging to the Asclepiadaceae. There is also a question whether *P. obliqua* has a limited or systemic mycelium or both. The name has been used by several authors for microcyclic forms which are often systemic, with pedicel usually attached obliquely, and with

mesospores intermixed. The specimen here recorded is of this type and is practically indistinguishable from numerous West Indian and South American specimens on various members of the family Asclepiadaceae.

PUCCINIA ROTUNDATA Diet. Hedwigia **36**: 32. 1897.

On *Vernonia brasiliana* (L.) Druce, *Kern* & *Toro* no. *7*.

A common rust in Colombia already reported on this species of host and two or three other species of the genus *Vernonia*.

UROMYCES HEDYSARI-PANICULATI (Schw.) Farl.; Ellis, N. Am. Fungi *246*. 1879.

Uredo amagensis Mayor, Mem. Soc. Neuch. Sci. Nat. **5**: 584. 1913.

On *Desmodium scorpiurus* (Sw.) Desv., *Kern* & *Toro* no. *8*. This is a new host for Colombia.

UROMYCES PROEMINENS (DC.) Pass. Rab. Fungi Eur. *1795*. 1873.

Uromyces euphorbiicola Tranz. Ann. Myc. **8**: 8. 1910.

On *Chamaesyce hypericifolia* (L.) Millsp., *Kern* & *Toro* no. *2*.

While this rust is common on this species of host in the West Indies, this is apparently the first report of it from Colombia on this host. It has been reported on *C. brasiliensis* and *C. hirta*.

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THE ROLE OF INTRACELLULAR MYCELIUM IN SYSTEMIC INFECTIONS OF RUBUS WITH THE ORANGE-RUST [1]

S. M. Pady

(with 42 figures)

It is well known that infections arising from basidiospores of either the short cycled aeciospores or the long cycled teliospores of *Gymnoconia interstitialis* become systemic and perennial. The orange-rust has perhaps been studied more extensively than any other rust possessing this type of infection. From the researches of Dodge (**5, 6, 7, 8**), and the earlier experiments of Kunkel (**12**), the following summary of our present knowledge regarding systemic infections may be made: Basidiospore infections from both the short and the long cycled strains become systemic when made upon young shoots of *Rubus* as they push through the ground in the spring; the mycelium establishes itself in the cambium and phloem and grows downward into the root crown; new shoots arising from the crown the following year will be rusted. A stimulation of shoot production each year results in a typical witches' broom. The mycelium is systemic and generally confined to the pith, except in the growing regions; shoots over 6 inches in height when inoculated become only locally infected since the mycelium is unable to reach the roots.

Further information is highly desirable, particularly as to the early stages of infection. While it is known where and when infection takes place, nothing is known of the actual method of penetration, the relation of the mycelium to the host cells and its method of development and distribution during the first year. In this paper the history of the infection has been followed in detail

[1] Published by permission of the National Research Council, Washington, D. C., as a National Research Fellow. The writer is also indebted to Dr. B. O. Dodge for his generous assistance and coöperation throughout the course of the investigations, and also to Prof. R. A. Harper for his interest and helpful suggestions, particularly in the preparation of the manuscript.

from the time of inoculation to the appearance of the rust the following year.

The inoculum was obtained from plants collected in the vicinity of New York, and by germination tests was shown to be clearly of the short cycled strain. The strain germinating with a two-celled promycelium was used in most cases, although the four-

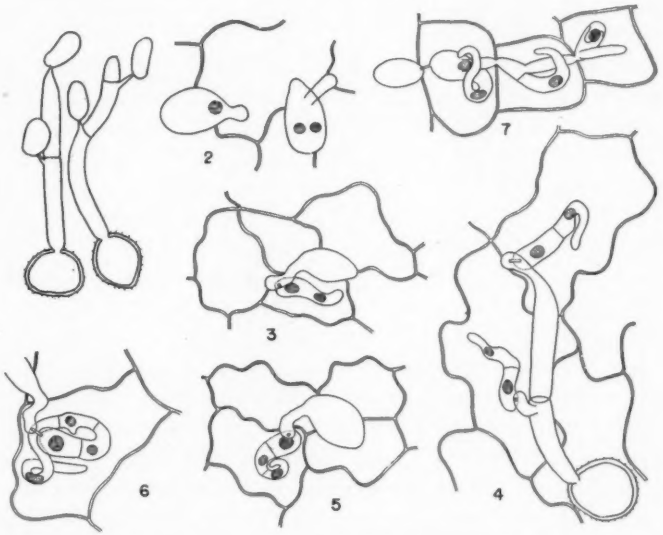


FIG. 1, typical germination of short cycled aeciospores on agar; 2, germinating basidiospores on leaf; 3, young penetration hypha in epidermis; 4, penetration directly from the promycelium after 2 days; 5-6, penetration hyphae of three and four cells; 7, young intracellular mycelium arising from a branch of the penetration hypha after 4 days. (Fig. 1 reduced to 400 ×, all other figures reduced to 600 ×.)

celled strain was also used and found to behave similarly. In order to obtain shoots for a series of inoculations, portions of roots from known healthy plants were layered in sand. When the shoots were about half an inch in length the spores were lightly dusted on with a camel's hair brush. At various intervals material was fixed for detailed study but in the main the results here presented are from freehand sections of fresh material. In a few cases leaves were inoculated in petri dishes as described in an earlier

paper (**13**). Penetration takes place readily on very young leaves, but as the leaf begins to mature penetration is accomplished only with great difficulty. This fact proved to be of considerable value since " in toto " preparations could be made from young inoculated leaves and the details of penetration and early mycelial development readily studied from them.

DEVELOPMENT OF THE INTRACELLULAR MYCELIUM

When sown upon young leaves in petri dishes or upon shoots kept in a moist chamber, germination takes place readily and the promycelia are fully formed within twenty-four hours (FIG. 1). As the basidiospores mature they are shot from the sterigmata and usually could be located a short distance away. Germination follows immediately and a short germ tube is formed (FIG. 2). Nuclear division sometimes occurs before penetration and the spores become binucleate (FIG. 2). From the rounded tip of the short germ tube a fine tube-like process is formed which passes through the cuticle and cell wall and enters the underlying host cell. The entire contents of the spore move through this opening and a short intracellular hypha begins to develop. The nucleus moves in and divides and the two nuclei can be readily seen (FIG. 3). This intracellular strand, the penetration hypha, continues to grow and the end usually becomes somewhat coiled.

An interesting feature of penetration by this short cycled rust is found in the behaviour of the sterigmata of some promycelia. As shown in figure 4, the sterigmata become rounded resembling the germ tubes of the basidiospore, and from this rounded part the penetration tube pushes out. In the upper cell the details of this process may be seen very clearly. This method of penetration seems to take place when the promycelium happens to lie in close contact with the epidermis, and is not infrequently encountered in inoculations made on leaves.

The penetration hypha grows slowly in the epidermal cell and the number of nuclei also increases. In the stage shown in figure 5 three nuclei may be readily observed. In these " in toto " preparations it is often difficult to see the cross walls of the hyphae, although the nuclei are very distinct. Further growth results in the formation of a characteristic penetration hypha (FIG. 6). The

basal cell is much enlarged and has a rounded outline. The second and third cells are narrower and the latter is sending out a branch. The terminal cell is becoming coiled in the epidermal host cell.

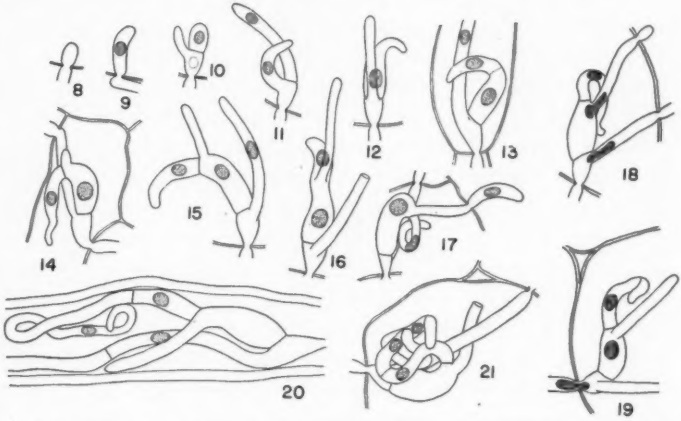


FIG. 8–17, development of intracellular mycelium showing stages in the formation of the runners and the terminal coil (see text for details); 18, nuclei beginning to move into the runners, secondary runner having just entered the adjacent cell; 19, nucleus in hypha passing through the opening in the cell wall; 20, intracellular mycelium in vascular tissue; 21, typical mycelium in pith after 100 days (note the compact multicellular terminal coil), runners practically empty. (All figures reduced to 600 ×.)

Up to this point the details of penetration agree very closely with the many accounts of basidiospore infection in the rusts. According to all of these accounts the penetration hypha gives rise immediately to an *intercellular* mycelium. In *Gymnoconia,* however, the penetration hypha sends out branches which enter adjacent cells to form a peculiar *intracellular* mycelium. From the basal cell of the penetration hypha a branch arises which grows to the side wall of the epidermal cell, forms a narrow opening and pushes through to the next cell. The intracellular mycelium which is thus initiated is characteristic in that a regular and definite hyphal system is formed in each cell entered. Figure 7 shows that the branch arising from the penetration hypha which has entered the next cell, has itself branched and given rise to a coiled hypha remarkably like the original penetration hypha. In the third cell,

which in this case is the limit of the intracellular development, the hyphal system is similar to that of the first two cells. It has been found that in every cell entered by this mycelium a similar development takes place, and this hyphal complex is so constant and characteristic that it may be readily recognized even in the presence of the hypha-like haustoria of the intercellular mycelium.

Various stages in the development of this mycelium are shown in detail in figures 8 to 17. These drawings show intracellular mycelium as found in different tissues and resulting from various inoculations. In figure 8 a young hypha has just entered a host cell. The opening is easily seen and there is a well marked but not extreme constriction at that point. This constriction is one of the characteristic features of this mycelium. The nucleus is near the tip and slips through the opening (FIG. 9, 17). Nuclear division takes place and a wall is laid down cutting off the tip. From the sub-terminal cell a branch arises (FIG. 10). For convenience the hypha so formed will be termed the *primary runner*. As growth continues the primary runner elongates rapidly, with the nucleus remaining in the tip, while the terminal cell elongates and bends either to one side or the other (FIG. 11). This stage is also shown in figure 12. The basal part of the terminal cell becomes much enlarged especially when compared with the primary runner (FIG. 12, 13). In the next stage the nucleus of the terminal cell divides (FIG. 13) and the enlarged terminal cell, now sub-terminal, sends out a branch just below the cross wall (FIG. 14). This branch is similar to the primary runner and will be referred to as the *secondary runner*. The secondary runner elongates rapidly (FIG. 15, 16) and pushes on into the next cell (FIG. 17, 18). In one or two cases this runner has been observed to branch before reaching the cell wall. The terminal cell also continues to grow but turns back upon itself forming a loose loop (FIG. 17). The nuclei, as they begin to move out into the runners, are often considerably attenuated (FIG. 18); once in the runners, however, they assume a more oval outline (FIG. 15, 17). Occasionally a nucleus is found in the process of passing through the opening in the cell wall. In figure 19 the nucleus has just commenced the passage and shows a well marked constriction.

It may be said then that at first the hypha in the cell is three-

celled; from the first cell arises the primary runner; from the second, which is characteristic in shape and size, the secondary runner is formed, while the third, or apical cell continues to grow slowly forming a rather complicated coil (FIG. 20, 21). When the runners enter the next cell each will give rise to a similar struc-

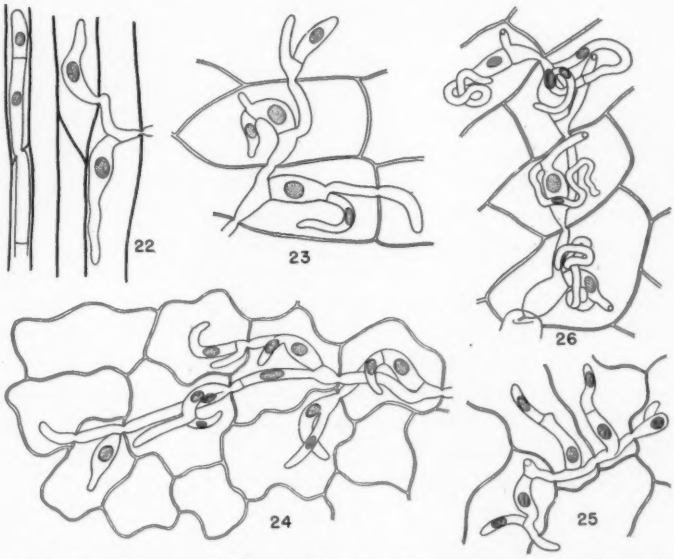
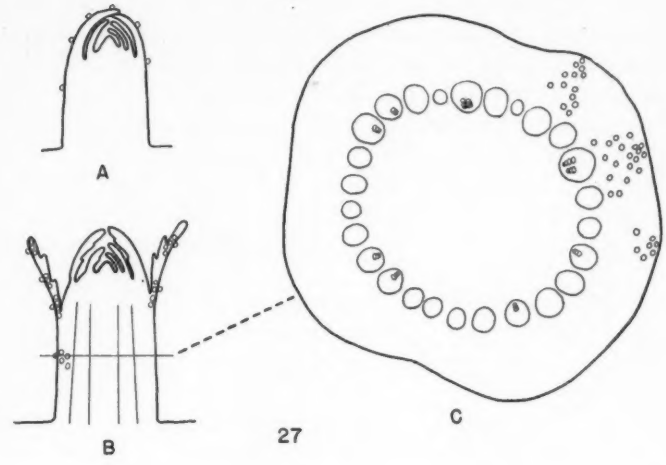


FIG. 22, young intracellular mycelium in phloem; 23, typical mycelium in cortex showing origin and development of the runners; 24, intracellular mycelium in epidermis of inoculated leaf; 25, mycelium in epidermis originating from a runner which entered from the palisade; 26, intracellular mycelium in epidermis showing infection hypha and part of the four-celled promycelium from which it arose; note coiling of tip and runners entering the leaf tissues below (indicated by a small circle), after 10 days. (All figures reduced to 600 ×.)

ture (FIG. 17). In figure 20 is shown a typical intracellular mycelium in the vascular region. The primary runner has advanced into an adjacent cell. The secondary runner has grown but a short distance, while the terminal coil has become two-celled and is greatly elongated. In older intracellular mycelia the two runners may appear to be almost empty while the apical unit is multicellular and much coiled (FIG. 21).

In figures 22 to 26 various hyphal strands of different ages and from different tissues are shown. The first two figures represent young hyphae in longitudinal section, figure 22 being from the vascular tissue and figure 23 from the cortex. The remaining figures represent various stages in leaf infections. If any of these strands be studied closely it will be at once apparent that one can interpret the mycelial structure in any one cell in terms of the units shown in figures 8 to 18. The mycelium which becomes established in the leaves is exceptionally favourable for study, since long hyphal strands are formed running from cell to cell in the epidermis (FIG. 24, 25, 26). The details of the formation of the primary and secondary runners may be readily observed in these figures. In the leaf all tissues are invaded, the mycelium travelling through the palisade and mesophyll and into both the upper and lower epidermis. In figure 25 a runner has entered the upper epidermis from the palisade and is growing in characteristic fashion. Figure 26 represents a hyphal complex in the epidermis arising from infection by a single promycelium, part of which is shown in the lower part of the drawing. From each of the four epidermal cells invaded by the mycelium, runners have entered the palisade layers below; such points are indicated by small circles in the drawing.

The distribution of the mycelium and the rate of growth was studied by making freehand sections of inoculated shoots at various intervals. At the end of five days the mycelium has invaded the cortex and has almost reached the scattered bundles. This is represented diagrammatically in figure 27; at *A* is a diagram of an inoculated shoot; *B* represents the same shoot 5 days later; at *C* is a cross section of the infected shoot drawn with camera lucida. The distribution of the mycelium is indicated by the small circles. In the cross section, *C*, the mycelium is well established in the cortex and has almost reached the young bundles. By the tenth day sections show that all parts of the vascular bundle have been invaded. Twelve days from the time of inoculation mycelium is abundant in the cortex, bundles and pith (FIG. 28). In the cross sections of this stage (FIG. 28*B*) the distribution of the mycelium suggests that infection has taken place at two major points on the shoot. From these points the mycelium has spread somewhat fanwise so that approximately one half of the bundles are infected.



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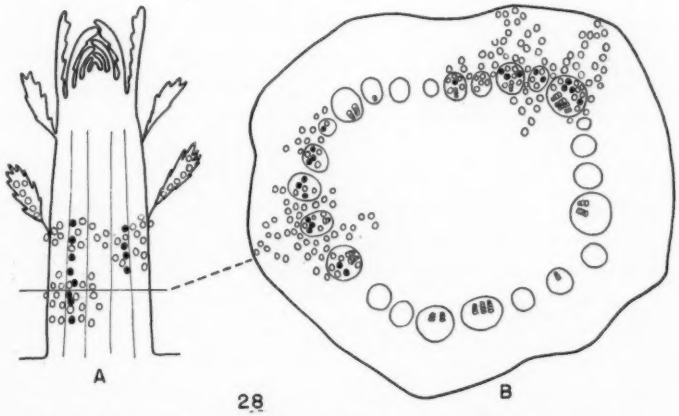

28

FIG. 27, diagram of 5 day old infection: *A*, shoot at time of inoculation; *B*, diagram of longitudinal section of shoot 5 days later; *C*, cross section of inoculated shoot drawn with camera lucida, × 720. (Circles ooo represent distribution of intracellular mycelium.); 28, diagram of 12 day old infection: *A*, inoculated shoot; *B*, cross section × 720; ooo = intracellular mycelium, ●●● = intercellular mycelium.

DEVELOPMENT OF THE INTERCELLULAR MYCELIUM

Longitudinal sections through infected shoots ten to twelve days after inoculation show that in the primary phloem a few long strands of intercellular hyphae are present. These strands are to be found only in the bundles in which the intracellular mycelium

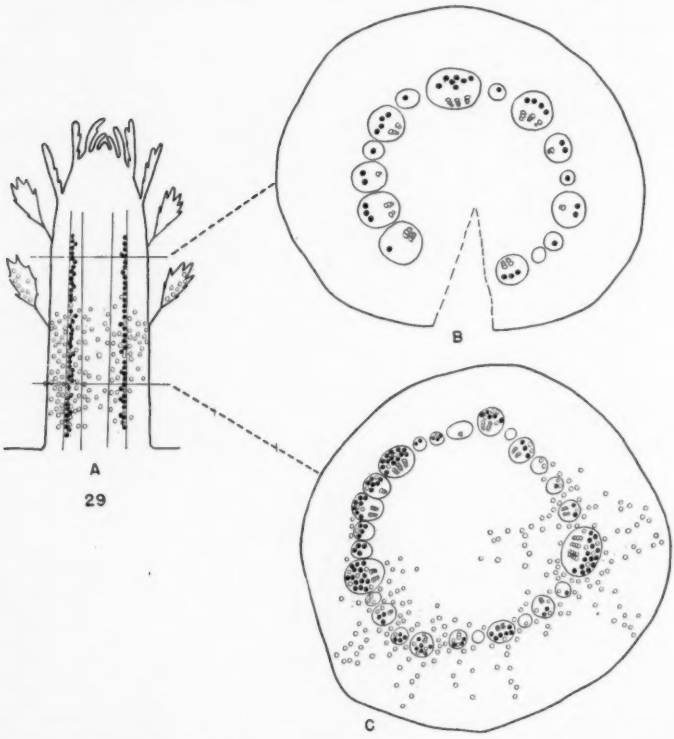

FIG. 29, diagram of 18 day infection: *B*, *C*, are cross sections at two different levels of shoot *A* × 720; ooo = intracellular mycelium, ●●● = intercellular mycelium.

is well established and are represented by the solid black circles (FIG. 28). By the 18th day both kinds of mycelium show a decided increase (FIG. 29). One shoot was analyzed at this stage and the distribution of the mycelium is shown in longitudinal sec-

tion at *A*, and in cross section at *B* and *C*. The intracellular mycelium has invaded practically the entire area at the level from which the section *C* was taken. Intercellular hyphae are present in the phloem of most of the bundles. In the larger bundles the number of strands may be rather high (FIG. 29*C*). Figure *B* is a cross section from near the tip of the shoot and shows that only the intercellular mycelium is present. This indicates clearly that the intercellular mycelium spreads rapidly upward while the intracellular mycelium is more or less confined to the region of original infection.

In cross section the intercellular hyphae bear a striking resemblance to the so-called companion cells of the host (FIG. 30). They are usually slightly irregular in outline and are generally located in the interstices of the cells. Occasionally, however, they run between the lateral walls (FIG. 30). This drawing, which is from an 18 day old infection, gives the impression that the intercellular hyphae run at a sharp right angle to the plane of the section. That this is not strictly true is indicated in figure 31. Here a few hyphae have been drawn at one particular focus (represented by the dark line) and at a lower level the same hyphae are again shown, this time by a dotted line. It is at once apparent that these hyphae pursue a somewhat irregular course through the phloem. In figure 32 one hypha has been drawn at four successive foci. At *A*, there are two distinct branches. Slightly below *A*, at *B*, they have united into one. At *C* the hypha is running at right angles to the plane of the section and spreading apart the walls of the two adjacent cells. Focusing just below this point we see that at *D* the hypha has again turned and is travelling downward. These figures represent the typical course of the intercellular hyphae in the phloem. In longitudinal section the hyphae are composed of rather short, uninucleate cells (FIG. 33). Haustoria are present in abundance in the well-established hyphal system (FIG. 33, 34). They are long, slender, multicellular and very hypha-like. The tip usually is slightly coiled, the amount of coiling apparently being dependent upon the size and shape of the host cell. In a large cell, as in the pith, the haustoria are more characteristic with a well defined coil at the tip (FIG. 35). This figure recalls very strongly the coil of the intracellular mycelium (FIG. 21).

During the progress of infection the young cane has been elongating rapidly. Dodge (**5**) has shown that the growing shoot leaves the fungus behind since the growing point is protected by the young leaves and is free from mycelium. Dodge believed that the fungus grew more rapidly downward than upward. A study

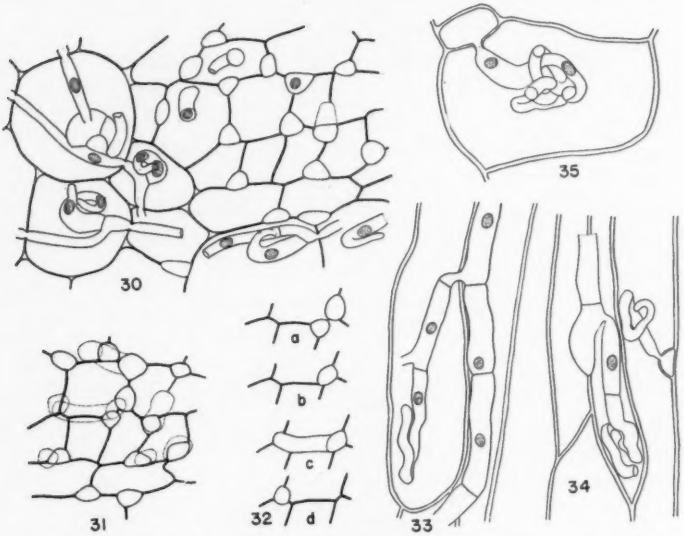

FIG. 30, inter- and intracellular mycelium in cross section, after 18 days; 31, intercellular strands at different levels (upper level shown by heavy line, lower level by dotted line); 32 *a–d*, four views of the same strand at four different foci; 33–34, typical intercellular mycelium in longitudinal section, showing haustoria; 35, haustorium in pith; compare with figure 21. (All figures reduced to 600 ×.)

of many shoots seems to indicate that while the mycelium does grow downward it also grows upward a considerable distance, as indicated in figure 29. At the end of 100 days one shoot had reached a height of 12 inches. The extreme tip had become injured and died. Sections revealed that the intercellular mycelium extended the entire length of the living shoot, while intracellular mycelium was found to be present only at the base of the cane. At the point where the cane joined the root both kinds of mycelium were present in abundance. The intercellular mycelium was not

confined to the pith and numerous strands were observed in the cortex. This indicates that in this case, at least, infection was successful since the mycelium was already present in the root system.

TRANSITION FROM INTRA- TO INTERCELLULAR MYCELIUM

Intercellular mycelium appears only after the intracellular is well established. The question then arises when, where and how does this change take place. From the foregoing data it may be concluded that the intracellular mycelium gives rise to intercellular hyphae in the phloem of the young bundles, from the 12th day of infection onward. The problem of the method by which this transition occurred was solved by a detailed study of freehand longitudinal sections of an infected shoot. It is possible to find in certain parts of the sections places where both kinds of mycelium are present. The method followed was to trace as far as possible individual intracellular hyphae. By careful search several places were found where the actual transition was taking place.

Six typical cases are shown in figures 36 to 41. In the first of these figures the primary runner instead of passing through the wall and into the next cell has entered the middle lamella, and turned at right angles to give the characteristic appearance of the intercellular hyphae. The secondary runner has continued the growth of the intracellular mycelium in the next cell. Figure 37 illustrates another method. Here the secondary runner has become an intercellular hypha. At *a*, the same hypha is shown at a lower focus. The characteristic wide opening which the runner makes as it enters the wall is shown in figure 38. The wall seems to extend along the runner for a short distance giving it a sheathed appearance. This is also indicated in figures 37, 40, 41. There is never any suggestion of a sheath surrounding the rest of the mycelium in the cell. Evans (**9**) in *Urocystis Cepulae* found a similar sheath on the penetration hypha near the point of entrance. In figures 39, 40, 41 the primary runner has become intercellular. The different aspects of this change, as one focuses downward, are shown in figure 40. At *a*, *b* and *c* the hypha has been drawn at three different foci; at *a*, making a wide opening in the wall; at *b*, the typical intercellular appearance; at *c*, moving obliquely to the

plane of the section. The young intercellular hypha grows in the middle lamella forcing the two walls apart. In figure 41 the intercellular hypha which has arisen from a primary runner, has grown along in the wall for some distance. In cases such as these the wall on each side of the hypha is clearly seen, and it is exactly one half the thickness of the common wall of the two host cells. It is extremely difficult to find cases of transition in the phloem. The cells are not only very narrow but they usually contain haustoria as well as intracellular mycelium. The cells of the pith and cortex being much larger afford a much better opportunity for studying these details. In these tissues they have been observed to arise from both the primary and secondary runners, but mainly from the former. The first formed intercellular hyphae in the phloem undoubtedly arise just as do those of the cortex and pith.

DESTINY OF THE INTRACELLULAR MYCELIUM

During the growing season the young infected plants were kept in pots in the greenhouse. In the fall they were transferred to a cold frame and allowed to rest until the first of February, at which time they were once more placed in the greenhouse. One plant was removed from the pot, brought into the laboratory and carefully studied. This plant was evidently infected since four small buds were present at the base of the cane. The infected cane was about 18 inches in height. Freehand sections revealed intercellular mycelium in phloem and cambium. The tip of the cane had been injured and as a result had died back to a point half an inch above the limit of the intercellular mycelium. All four buds showed vigorous hyphae and haustoria in the growing points. Had these buds been allowed to grow all of the leaves would have been rusted.

At the end of the growing season the intracellular mycelium had been found to be largely confined to the basal part of the cane. It was of interest, therefore, to see what changes may have taken place in this mycelium as a result of overwintering. Sections through the old cane about one inch from the root showed that the intracellular mycelium was still present but did not appear to be in an active state of growth. The hyphae were clearly distinguishable though practically devoid of contents.

Four to five weeks later rusted leaves began to appear on the

inoculated plants in the greenhouse, indicating that the infections had been successful. In figure 42, *A*, is shown a photograph of one of these infections. At the time of inoculation (May 31st) the shoot had grown about an inch from the root cutting. Free-

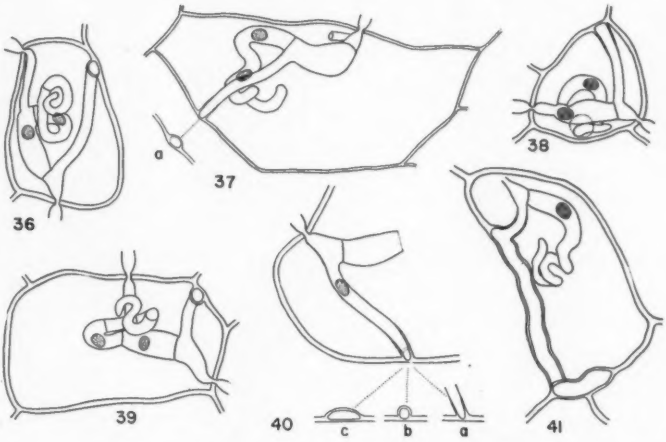

FIG. 36–41, transition from intra- to intercellular mycelium; 36, primary runner becoming intercellular; 37, secondary runner becoming intercellular; at a lower focus, *a*, it is clearly intercellular; 38, wide opening in cell wall and sheath near point of entrance; 39, primary runner becoming intercellular, the secondary runner continuing the intracellular growth; 40, transition of the primary runner at three foci: *a*, entering the cell wall; *b*, same hypha in the wall; *c*, the hypha is running obliquely in cell wall; 41, secondary runner becoming intercellular and running horizontally in the cell wall. (All figures reduced to 600 ×.)

hand sections from this and other plants showed very little intracellular mycelium. A few strands were observed in the cortex and these appeared to be in the initial stages of degeneration. The plant illustrated in figure 42, *B*, shows a young infection on *Rubus occidentalis* with the infected shoots in a dormant condition. Each year the number of new infected shoots will be augmented so that in a few years the plant has assumed a typical witches' broom appearance (FIG. 42, *C*, *D*).

Having followed the course of infection from basidiospore penetration to the appearance, a year later, of aecia on the newly opened

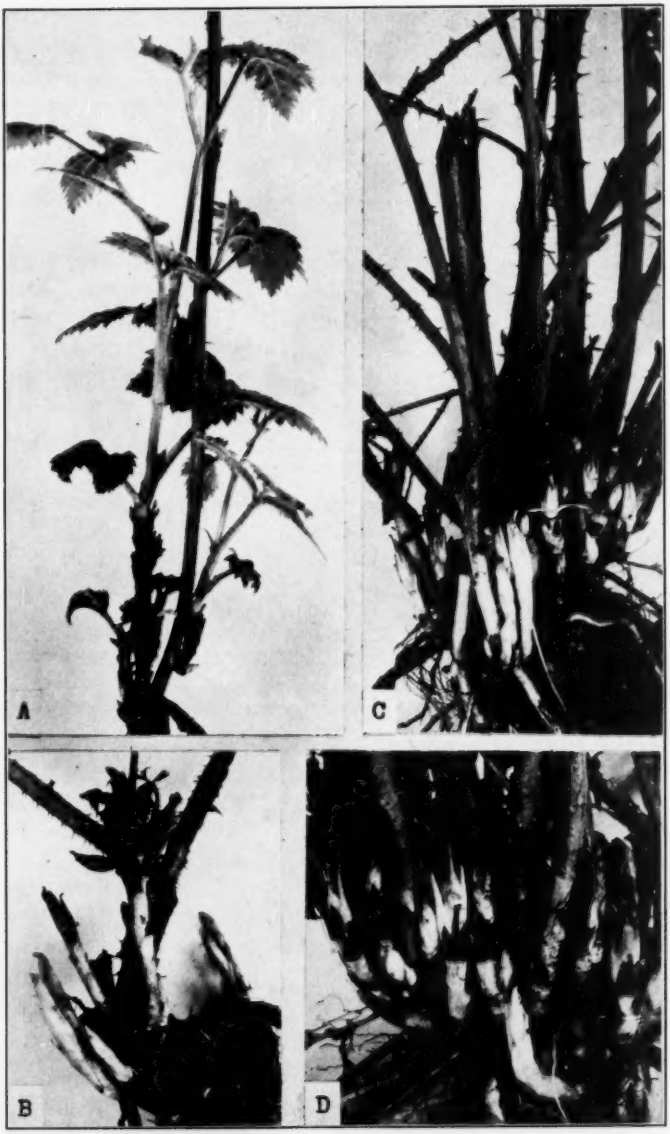

FIG. 42

leaves, it becomes possible to study the role and destiny of the intracellular mycelium in the light of the complete story of infection. This mycelium is prominent in the earliest stages and by its penetration of all tissues makes possible the development of the first intercellular strands in the phloem. By its very nature the intracellular mycelium is apparently inadequate to meet the conditions arising in a young growing shoot. Intercellular hyphae, growing longitudinally, are able to keep pace with the rapidly growing cane. At first the intracellular hyphae probably act in an haustorial relation to the intercellular hyphae, but as soon as the latter develops haustoria of its own, it becomes independent. Throughout the growing season, however, new intercellular runners are continually being formed, so that by the end of the growing season a considerable amount of mycelium has been produced. When growth begins again the following spring the intercellular mycelium continues its independent development. There is therefore no further necessity for continued intracellular growth. The evidence seems to indicate that during the following year the mycelium gradually degenerates. At the end of the second year the originally infected cane dies out and with it all traces of the primary infection disappear.

DISCUSSION

Intracellular mycelia are not uncommon in other groups of fungi. The mycelium of certain of the Polyporaceae is regularly intracellular, while in the smuts it is often both inter- and intracellular. In the ascomycetes and fungi imperfecti many cases have been reported, while in the phycomycetes intracellular mycelium is well known, as for instance in *Rhizopus* on strawberries. Miss Rice (**15**) has reviewed the literature on intracellular parasites up to 1927 and an extensive review is not necessary here. The significant thing about the majority of the intracellular forms, as compared with the present case, is that the mycelium runs from cell to cell with little or no branching, and without notable differentiation. The opening in the cell wall through which the fungus passes is often a broad one, sometimes being even larger than the diameter of the hypha (**11**). The intracellular mycelium here reported differs radically in that it is highly differentiated in each cell. This

differentiation is so constant and characteristic that it can be readily identified even when haustoria of the intercellular mycelium are present in the same cell.

Intracellular mycelium is not necessarily associated with saprophytism. It has been reported in the Auriculariales in *Eocronartium* by Fitzpatrick (**10**), a species which shows a high degree of parasitism. In the rusts, however, so far as I have found, intracellular mycelium has not been thus far reported. The rusts are characterized by intercellular mycelia with haustoria in the cells of the host. Apparently an especially delicate balance between the parasite and the host is established under these conditions. The presence of a well developed mycelium entirely within the cells might result in an even more intimate relationship, such as is found in mycorrhiza and in certain chytrids. It would be very desirable to make a cytological study of the host-parasite relations in connection with the intracellular mycelium in *Gymnoconia.*

In those rusts in which the development of the haploid mycelium has been studied there is a brief intracellular phase which is usually confined to a single cell. The penetration hypha of the basidiospore is generally intracellular, and often considerably branched (**2, 3**). In *Endophyllum Sempervivi* the situation has recently been shown by Miss Ashworth (**4**) to be similar. The writer, however, has observed that the penetration hypha sometimes forms an extensive mycelium in the large epidermal cells of *Sempervivum.* Hyphae have been observed to follow the complete circumference of the host cell, as if seeking a point of egress. These hyphae are multicellular and this case may be considered as that of a very localized intracellular mycelium. Miss Allen in one of her cytological studies on heterothallism (**3**) has reported that occasionally receptive hyphae are intracellular. The aeciospores of the long cycled strain of *Gymnoconia interstitialis* penetrate the leaf with a short intracellular penetration hypha which arises from an appressorium (**13**). The teliospores of the genera *Milesia, Calyptospora, Hyalopsora* and *Thecopsora* of the Pucciniastreae are intracellular in the epidermis of their hosts (**14**).

In many rusts the haustoria are long, filamentous, multicellular and branching. Sometimes the lumen of the cell is filled (**5**). Haustoria of this type have also been observed by the writer in

Endophyllum Sempervivi and in *Puccinia curtipes.* In these cases the haustorium is simply a localized intracellular mycelium. If the haustorium should grow into adjacent cells the situation would be somewhat analogous to that of the intracellular mycelium here reported for the orange-rust. Miss Allen (**1**), in noting the somewhat mycelium-like nature of the primary infection hypha, states: "It is probable, however, that all of these intracellular growths, whether haustorial in form or intermediate between that and ordinary hyphae, are haustorial in function." The haustorial nature of the intracellular mycelium is at once suggested when comparisons are made with typical haustoria (FIG. 21, 35). The coiled tip of the intracellular mycelium is similar in appearance to the regular haustorium. The two basal cells are formed in connection with the development of the runners.

The intercellular condition supervenes as soon as the phloem has been reached. The cause of this change involves some very interesting problems in parasitism. Both mycelia continue their growth, often side by side, and intercellular strands are continually being formed. Even after haustoria have been developed the intracellular mycelium continues to grow although it appears to slow down as the season progresses. The important fact in this type of infection is that the intercellular mycelium apparently must reach the roots before the end of the growing season. The intracellular mycelium is perhaps the most rapid means of reaching the phloem from the exterior. The ability of the runners to become intercellular and the general downward growth of the mycelium throughout the season, are factors of primary importance in the establishment of the systemic infection.

SUMMARY

Basidiospores of the two short cycled strains of the orange-rust, *Gymnoconia interstitialis,* when sown on young shoots of *Rubus,* penetrate the epidermis and form a typical penetration hypha.

From this hypha intracellular branches arise which enter adjacent cells passing through the side walls of the host cell. As the hypha enters the next cell, it cuts off a tip cell. The subterminal cell gives rise to a branch called the primary runner. The

terminal cell divides again and this sub-terminal cell also gives rise to a runner called the secondary runner. This cell is much enlarged with a characteristic rounded base. The terminal cell continues to grow, becoming more or less compactly coiled and multicellular. The runners enter neighbouring cells and each repeats this procedure. The result is a highly characteristic intracellular mycelium.

The mycelium grows in this way through the cortex into the vascular bundles and into the pith. From the 10th day onward and continuing throughout the season strands of intercellular mycelium begin to appear in the phloem. These arise from one of the runners, usually the primary runner, which grows into the middle lamella and the intercellular spaces. The intercellular mycelium grows rapidly in the phloem and becomes established as a perennial mycelium in the cane and in the roots.

The function of the intracellular mycelium seems to be that of establishing the fungus in the host, and is probably haustorial in nature. Little, if any, growth of the intracellular mycelium takes place the following spring and the evidence indicates that degeneration takes place later.

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EXPLANATION OF FIG. 42

FIG. 42, *A*, one of the infected plants of blackberry a year after inoculation (note the new shoots at the base of the cane); *B*, dormant infected plant of *Rubus occidentalis* from nature; this plant having not been long infected, as indicated by the small number of new shoots; *C–D*, photograph of the crowns of old established infections on blackberry showing the many new shoots in a dormant condition, when leaves mature on these shoots they will all be rusted. (The above-ground parts form a characteristic witches' broom.)

SPUMULA, A NEW GENUS OF RUSTS

E. B. MAINS [1]

(WITH 1 FIGURE)

While consulting phanerogamic specimens in the Herbarium of the University of Michigan, a rust was noted on a specimen of *Calliandra bijuga* Rose which had been collected by Ynes Mexia in Jalisco, Mexico, February 4, 1927. An examination showed that this presented some very unusual features. After a comparison with related species of rust, it has been concluded that it is an undescribed species belonging to a new genus for which the name *Spumula* is proposed.

Spumula gen. nov.

Aecia subepidermalia, poculiformia, peridio instructa; telia subepidermalia, pulverulentia; teliosporae hemisphaericae, compositae ex 4 (raro 3) cellulis a latere conjunctis; cystidia semper fere 4, globosa pendula; pedicellus longus, ex una hypha compositus.

Spumula quadrifida sp. nov. aeciis minutis 0.2–0.3 mm., hypophyllis, sparsis vel aggregatis, poculiformibus vel cylindricis; cellulis peridii rhomboideis, 14–20 × 20–26 μ, dense minuteque verrucularis, pariete exteriore 5–6 μ crassa, interiore 2–2.5 μ; aeciosporis late ellipsoideis, 12–16 × 16–22 μ, minutissime verruculosis, membrana hyalina 1 μ crassa; teliis hypophyllis, sparsis vel circum aecia aggregatis, pulverulentis, fulvis; teliosporis levibus, 42–54 μ latis, 26–30 μ crassis, ex 4 cellulis (raro 3) compositis, fulvis; cystidiis 4, hyalinis, 10–14 × 16–26 μ; pedicellis fragilibus, hyalinis, quibusque ex una hypha compositis. (FIG. 1 *A, B.*)

In foliis Caliandrae bijugae. Legit Ynes Mexia (1638 A), inter San Sebastian et Real Alto, Jalisco, Mexico, Feb. 4, 1927. In Herbario Universitatis Michiganensis conservatum.

Aecia hypophyllous, scattered or in groups of two or three, cupulate to cylindric, small, 0.2–0.3 mm. in diameter; peridial cells rhombic in side view, 14–20 × 20–26 μ, the outer wall 5–6 μ thick, the inner 2–2.5 μ, finely and closely verrucose; aeciospores broadly ellipsoid 12–16 × 16–22 μ, the wall colorless, 1 μ thick, very finely verrucose. Telia hypophyllous, scattered, often closely associated

[1] Papers of the Department of Botany and the Herbarium of the University of Michigan, no. 540.

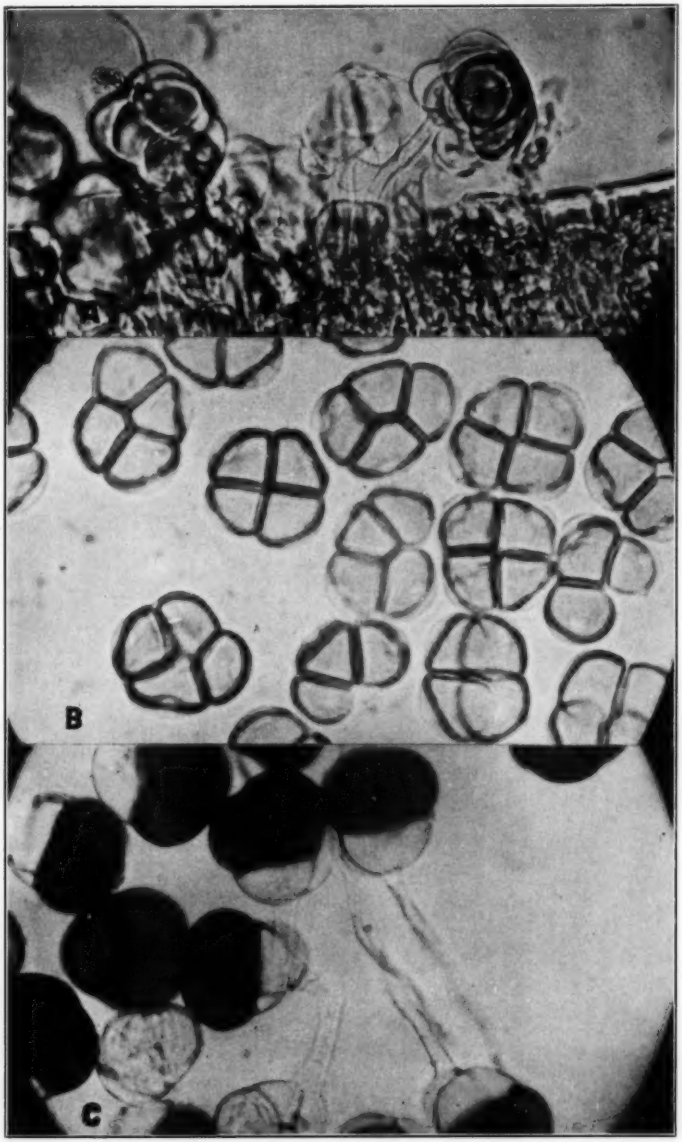

FIG. 1. *A, B, Spumula quadrifida; C, Cystomyces costaricensis.*

with the aecia; teliospores sometimes developing in old aecia, pulverulent, cinnamon-brown; teliospores smooth, 42–54 μ in diameter, 26–30 μ thick, usually consisting of four cells, the walls golden brown, 1.5–2 μ thick, the germpore covered with hyaline thickening, 4–6 μ, cysts hyaline, usually one to each cell, 10–14 $\times$ 16–26 μ; pedicel fragile, colorless, simple.

On *Calliandra bijuga* Rose, trail from San Sebastian to Real Alto, Jalisco, Mexico, Ynes Mexia (*1638*, type), Feb. 4, 1927.

The pulverulent telia, due to the fragile pedicels of the teliospores, superficially have the appearance of uredinia. Uredinia, however, are lacking. The small aecia are scattered or in groups of two or three. They are small and inconspicuous. They are not accompanied by pycnia indicating that they may be repeating aecia. Several were found to contain teliospores in addition to aeciospores. The teliospores are mostly four-celled, the cells laterally united into a head. A hyaline cyst is more or less pendant beneath each cell. A number of teliospores were found with basidia indicating that germination probably occurs without a long rest period.

This rust might be considered a simple *Ravenelia* in which no fusion has occurred. In this respect *Ravenelia simplex* Diet. approaches it. Although the latter species has some simple spores, most are compound as in the majority of species of *Ravenelia*. In *Spumula quadrifida* the pedicel of the teliospore is a single hypha and there is no evidence of a fusion of teliospores.

The simple pedicel immediately suggests the genus *Cystomyces*. At present only one species is known, *Cystomyces costaricensis* Syd. This is a short-cycled species. Both Sydow and Dietel [1] have emphasized the occurrence of a simple pedicel in separating this genus from *Ravenelia*. Through the kindness of Dr. David H. Linder it has been possible to examine material of *C. costaricensis* from the Farlow Herbarium. The structure of the teliospore of *Cystomyces* differs markedly from that of *Spumula*. In *Cystomyces costaricensis* the spore is formed of three dark colored cells laterally united. Below there are three hyaline cysts also

[1] Sydow, H. Fungi in itinere costaricensi collecti. Ann. Myc. **24**: 290–292. 1926. Dietel, P. Uredinales. Engler—Prantl Natürlichen Pflanzenfamilien 2 Auf. **6**: 70–71. 1928.

closely united, the whole forming a somewhat irregular globoid head (FIG. 1*C*). The simple pedicel is attached to the cysts and not to the dark colored cells as in Spumula. The differences are illustrated in figure 1. *Spumula* is apparently more closely related to *Ravenelia* than to *Cystomyces*.

EXPLANATION OF FIGURE

A, Spumula quadrifida, side view of teliospore (Note simple pedicel and pendant cysts); *B, Spumula quadrifida* showing quadrifed horizontal arrangement of cells of the teliospores; *C, Cystomyces costaricensis* (Sydow, Fungi exotici exsiccati *595*), contrast with *A* and *B* (Note attachment of pedicel to the coherent cysts); all × 440.

NEW OR NOTEWORTHY BASIDIOMYCETES FROM THE CENTRAL ROCKY MOUNTAIN REGION

FRED J. SEAVER AND P. F. SHOPE

(WITH 4 FIGURES)

This paper deals with some new or noteworthy species of Basidiomycetes collected in Colorado and Wyoming during the summer of 1929 by the senior author from the New York Botanical Garden, and the junior author from the University of Colorado and a resident of Colorado. A brief synopsis of the activities of the authors during the summer of 1929 has previously been published (**7**). Also, a report covering the rusts which were collected has already been made (**9**).

Based entirely or in part upon the Basidiomycetes collected in 1929, one new genus and two new species have already been reported, as follows: *Calbovista subsculpta* Morse (Mycologia **27**: 97. 1935) and *Phlebia mellea* Overholts (Mycologia **22**: 241. 1930). This present paper presents one additional new species.

Complete and annotated check-lists of all the Basidiomycetes, except the rusts, collected by the authors in Colorado, Wyoming, and South Dakota, will appear in the "University of Colorado Studies," Volume 23, number 2. 1935. This paper deals with one new species, and other species of interest in respect to their geographical and altitudinal distribution, host relations, and morphological characteristics.

DACRYOMYCETACEAE

DACRYOMYCES ABIETINUS (Pers.) Schröt. On dead decorticated *Picea Engelmanni.* Middle Boulder Canyon, Colo., No. *25* and *53;* University of Colorado Summer Camp, No. *146.* Also, collected in Colorado by the junior author in 1927 and 1928 on the same host. This is the first report of this species from Colorado and from the Rocky Mountain States. Dur-

ing the summer and autumn of wet years, this species is of frequent occurrence.

HETEROTEXTUS ALPINUS (Tracy & Earle) Martin, Mycologia **24**: 217. 1932.

Guepinia alpina Tracy & Earle, in Greene, Pl. Bakerianae **1**: 23. 1901.

Guepinia monticola Tracy & Earle, *ibid.*

Ditiola Shopei Coker, Jour. Elisha Mitch. Soc. **46**: 117. 1930.

On dead *Picea Engelmanni.* Middle Boulder Canyon, Colo., No. *2.*

This is a common species in the Central Rocky Mountain region in wet springs and summers. During late summer and autumn, when conditions of moisture are inadequate, this species is frequently rare.

The junior author has noted that the distribution of this species in Central Colorado extends from approximately 7,000 feet to 11,300 feet in elevation, and it is most abundant at elevations of from 9,000 feet to 11,000 feet.

Young fructifications are almost globose; later, they become cup-shaped, with the hymenium either plane, concave, or convex depending upon the abundance of moisture. They have been found to be as large as 14 mm. in diameter. The hymenium is most always superior.

TREMELLACEAE

TREMELLODON GELATINOSUM (Scop.) Pers. On dead *Picea Engelmanni.* North Park, Colo., elevation 10,000 feet, No. *535;* and Grand Mesa, Colo., elevation 9,000 feet, No. *558.*

This is the first report of this species from Colorado and the Rocky Mountain States. A large and excellent collection of this interesting fungus was made at Grand Mesa in September following a rainy period of over one week in duration (FIG. 4).

Other interesting tremellaceous fungi collected in Colorado and not previously reported from either Colorado or the Rocky Mountain States are: *Tremella lutescens* Pers. On dead *Populus tremuloides,* Tolland No. *469;* and *Tremella pinicola* Beritz. On dead *Picea Engelmanni,* Pikes Peak, No. *458.*

THELEPHORACEAE

ALEURODISCUS AMORPHUS (Pers.) Raben. On twigs of dead *Picea Engelmanni*. Collected by Dr. E. Bartholomew and the junior author at Tolland, Colo., No. *471* (FIG. 1*a*).

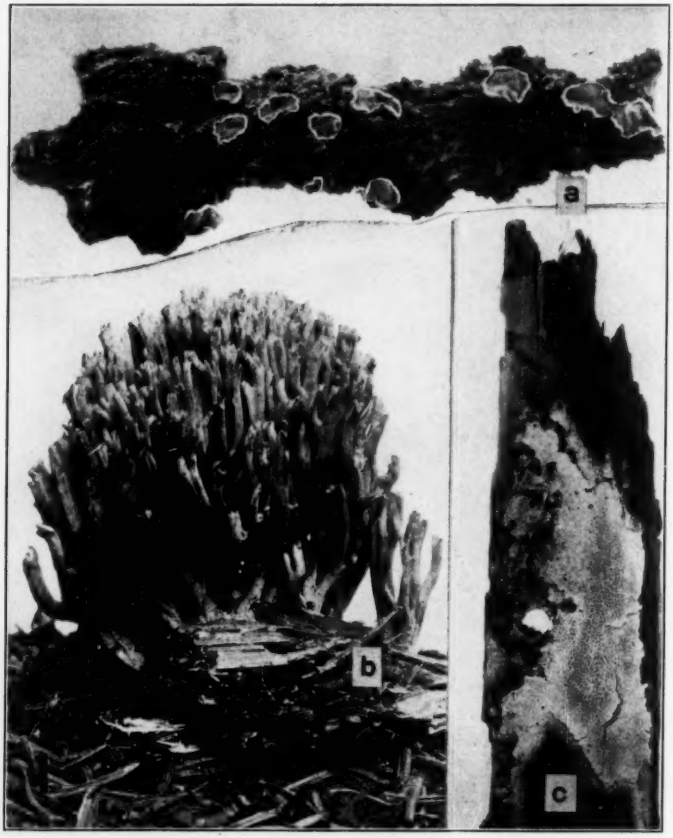

FIG. 1. *a, Aleurodiscus amorphus; b, Clavaria apiculata; c, Merulius fugax.*

A previous collection of this fungus made by the junior author in Colorado in 1928, was sent to Dr. L. O. Overholts, and reported by him (Mycologia **25**: 426. 1933). This species is also known to occur in Idaho, and its discovery in Colorado points to its distribution throughout the Rocky Mountain system.

CORTICIUM LACTEUM Fries. On dead decorticated *Picea Engelmanni*. University of Wyoming Summer Camp, No. *195*. First report from Wyoming. Previously known to occur in the Rocky Mountain States in Idaho and Colorado.

CYPHELLA FASCICULATA (Schw.) Berk. & Curt. On dead *Salix* sp. University of Colorado Summer Camp, No. *95*. New host. Previously known to occur chiefly on *Alnus*, and rarely on *Prunus* and *Pyrus*. Identified by Dr. L. O. Overholts.

This fungus has a wide distribution in Eastern United States with Wisconsin and Alabama representing the western limits of

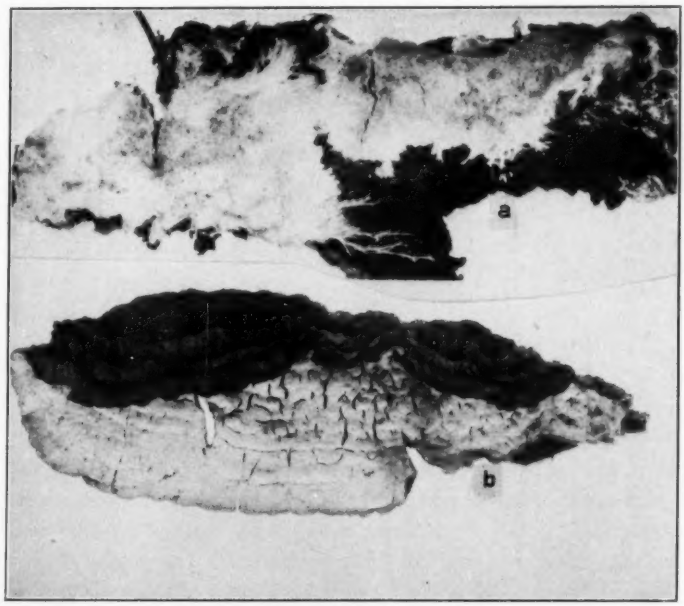

FIG. 2. *a, Peniophora carnosa; b, Stereum rugisporum.*

its distribution. Several collections of this species have recently been reported from Oregon (**3, 11**).

The discovery of this species in Colorado represents the first collection from the Rocky Mountain States and west of Wisconsin and Alabama.

PENIOPHORA CARNOSA Burt. On dead *Populus tremuloides*. University of Wyoming Summer Camp, No. *200*. The junior author in 1928 collected this fungus in Colorado on the above host (Shope Herb. No. *450*) (FIG. *2a*).

This species is usually found on the bark and wood of coniferous logs, rarely on frondose species. Since this fungus has previously been reported from Montana, Idaho, and New Mexico by Dr. Burt (**2**), its discovery in Wyoming and Colorado in abundance further proves Dr. Burt's statement: "Common in the Rocky Mountain forests" (l. c.).

STEREUM RUGISPORUM (Ellis & Ev.) Burt. On dead *Picea Engelmanni*. Near Brooklyn Lake, Wyo., elevation 10,500 feet, No. *239*; and same host, Middle Boulder Canyon, Colo., elevation 10,000 feet, No. *58* (FIG. *2b*).

As reported by Dr. Burt (**1**), this species is of common occurrence in the Rocky Mountain States on various species of conifers. In moist years it is abundant. It is found most frequently at elevations of from 10,000 feet to 11,000 feet. The junior author is of the opinion that this species is occasionally perennial.

POLYPORACEAE

Our collections of pore-fungi in Colorado yielded nothing of outstanding interest that has not already been reported by the junior author in a previous publication (**8**). The pore-fungi of Wyoming, however, have received very little consideration in our literature. Therefore, the few species collected in that state throw some light upon the distribution of these species in the Rocky Mountain States. All species collected in Wyoming occur also in Colorado. *Fomes Pini* (Thore) Lloyd, *Polyporus alboluteus* Ellis & Ev., and *P. leucospongia* Cooke & Hark. occur in Colorado, Wyoming, and according to Dr. Weir (**10**) in Montana. *Polyporus circinatus* Fries and *P. ursinus* Lloyd, however, seem to reach their northern limit of distribution in Wyoming, since they have not been reported from Montana (l. c.).

MERULIUS FUGAX Fries. On dead *Pinus Murrayana*. Grand Mesa, Colo., No. *578*. First report from Colorado (FIG. 1*c*).

This fungus is known to occur in Idaho, and its occurrence in Colorado points to its distribution throughout the Rocky Mountain region. The junior author knows of three collections of this species from Colorado all of which were made from the same type of host.

CLAVARIACEAE

CLAVARIA APICULATA Fries. On rotted coniferous wood. Middle Boulder Canyon, Colo., No. *55;* and Grand Mesa, Colo., No. *560* (FIG. 1*b*).

Dr. Coker (**4**) reports this fungus as occurring in the Eastern States and Washington. This Colorado collection is apparently the first report of the occurrence of this species in the Central United States and the Rocky Mountain region.

AGARICACEAE

AMANITA MUSCARIA (L.) Fries. On the ground under conifers. University of Wyoming Summer Camp, No. *196;* and Tolland, Colo., No. *477*.

In a recent article entitled, "Mycofloristic impressions of a European mycologist in America," by Mr. J. E. Lange (**6**), he notes that: "While in Europe *Amanita muscaria* is almost always bright scarlet—, all over the Eastern States a similar species but with a clear orange-yellow hue occurs. The existence of this orange-colored American form is the more remarkable because the scarlet European type also occurs in certain parts (*e.g.* the eastern Canadian provinces and Oregon, where it is said to attain gigantic dimensions)." Dr. Kauffman was the first to point out the occurrence of this scarlet-colored fly-mushroom in Colorado (**5**), and the authors of this paper found again this agaric with the typical coloration of the European plant. This scarlet-colored form was found also in Wyoming, and thus indications point to its still wider distribution in the Rocky Mountain region. Although Dr. Kauffman's collections in Colorado, as well as our collections from Colorado and Wyoming, were made at elevations of from 9,000 feet to 10,000 feet, this does not indicate that the

scarlet-colored form occurs in the United States only at relatively high elevations. Dr. Zeller has collected this scarlet form in Oregon in pine barrens along the coast (**12**).

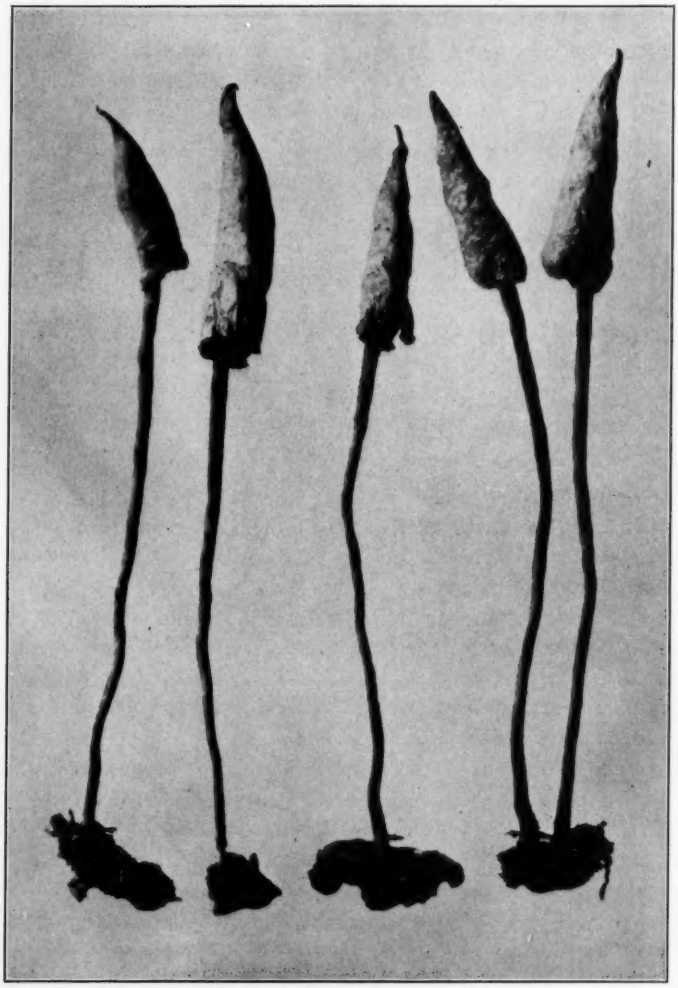

FIG. 3. *Bolbitius cucullatus.*

Bolbitius cucullatus Shope & Seaver, sp. nov. (FIG. 3).

Pileus 6–10 mm. broad, 25–40 mm. high, conical, not expanding, cinereous to pale yellow when fresh, drying Cinnamon-Buff (Ridg.) to Clay Color (Ridg.), subviscid, even, glabrous; apex cuspidate, concolorous; margin inturned or straight, acute, lacerate with age, concolorous; context less than 1 mm. thick, whitish; lamellae adnexed, close, 0.5–2 mm. broad, whitish, with age becoming brownish-ochraceous, drying Vandyke Brown (Ridg.), dissolving slightly with age; stipe 10–12 cm. long, 1–2 mm. thick, equal, flaccid, glabrous to slightly floccose, stuffed or hollow, concolorous with the pileus, drying striate, bulbous at the base; spores ellipsoid to ovoid, sometimes apiculate, smooth, ochraceous under the microscope, 12–16 × 8–10 μ.

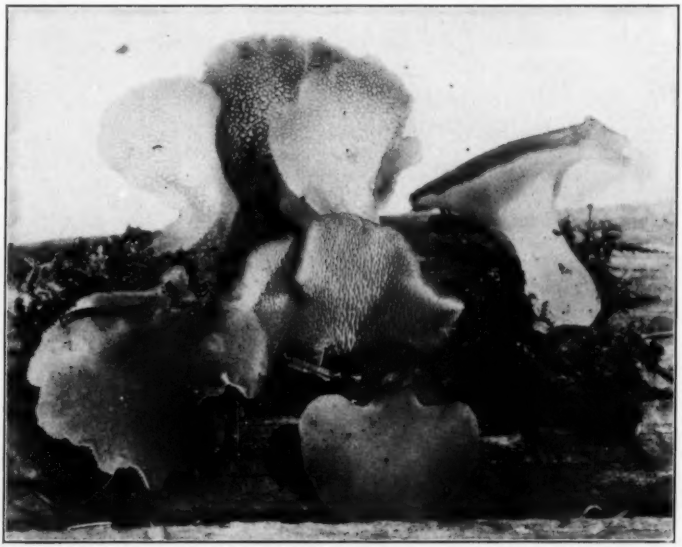

FIG. 4. *Tremellodon gelatinosum.*

Pileo tenerrimo, elongato-conico, levi, subviscido, cinereo vel flavo, apice cuspidato aut cucullato, 6–10 mm. lato, 25–40 mm. longo; stipite gracile, fistuloso, basi leviter incrassato, 1–2 mm. lato, 10–12 cm. longo; sporis ellipsoideis vel ovoideis, saepe apiculatis, ochraceis, 8–10 × 12–16 μ.

Type collection No. *249*. Gregarious to scattered. Among grass near the University of Wyoming Summer Camp, elevation 9,600 feet, August 2, 1929. Known only from the type collection.

This new species is well marked and distinct. Its closest affiliation is *Bolbitius tener* Berk., to which it is related by its similar spore and hymenial characteristics. It differs from *B. tener* in that the upper part of the pileus is drawn out into a cusp; the pileus does not finally expand; the stipe may at times be stuffed, and the new species is more than twice the size of the former species. About fifty specimens were collected and several hundred others observed all of which had the characteristics that are described above.

LYCOPERDACEAE

CALBOVISTA SUBSCULPTA Morse, Mycologia **27**: 97. 1935. On the ground under conifers. Middle Boulder Canyon, Colo., elevation 10,000 feet, July 23–28, No. *36;* and University of Wyoming Summer Camp, elevation 9,600 feet, August 1–3, No. *192*. This latter collection from Wyoming was not mentioned in Miss Morse's paper, and it adds another state to the range which to date includes California, Washington, Idaho, Colorado, and Wyoming. This fungus is evidently found only at high elevations throughout the Rocky Mountain region and the Western Coastal ranges.

UNIVERSITY OF COLORADO,
THE NEW YORK BOTANICAL GARDEN

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EXPLANATION OF FIGURES

Fig. 1. *a, Aleurodiscus amorphus* (Pers.) Raben.; *b, Clavaria apiculata* Fries; *c, Merulius fugax* Fries; all natural size.

Fig. 2. *a, Peniophora carnosa* Burt; *b, Stereum rugisporum* (Ellis & Ev.) Burt; both ½ natural size.

Fig. 3. *Bolbitius cucullatus* Shope & Seaver, natural size.

Fig. 4. *Tremellodon gelatinosum* (Scop.) Pers., ½ nature size.

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